Review of Particle Properties

Particle Data Group

ANGELA BARBARO-GALTIERI, STEPHEN E. DERENZO, LEROY R. PRICE, ALAN RITTENBERG, ARTHUR H. ROSENFELD
Lawrence Radiation Laboratory, University of California, Berkeley, California*

NAOMI BARASH-SCHMIDT
Brandeis University, Waltham, Massachusetts

CLAUDE BRICMAN, MATTS ROOS
CERN, Geneva, Switzerland

PAUL SÖDING
DESY, Hamburg, Germany

CHARLES G. WOHL
Oxford University, Oxford, England

This review of the properties of leptons, mesons, and baryons is an updating of Review of Particle Properties, Particle Data Group [Rev. Mod. Phys. **41**, 109 (1969)]. Data are evaluated, listed, averaged, and summarized in tables and wallet sheets. A data booklet is also available.

CONTENTS

I. INTRODUCTION AND CREDITS

This review is an updating through October 1969 of Particle Data Group (1969), with minor changes.

In this text we concentrate on topics that are either new or essential. For complementary information on our standard procedures, the reader is referred to the 1969 text.

Among the essential items is our perennial remark that it is inappropriate to make reference to this compilation instead of to an original work (to which we even provide a handy citation), but some people still just quote us, without warning the reader that ours is a review and not an experiment. To emphasize this point we ask that this article be referred to as "Review of Particle Properties" and that the tables with the averaged values be referred to as "Particle Properties Tables." Further, please attribute them to the Particle Data Group rather than to individuals.

To make communication easier we now state who has concentrated on each major area. The list for the last 12 months is:

Stable Particles: N. Barash-Schmidt, A. Barbaro-Galtieri, and Stephen E. Derenzo. Our European consultant is Matts Roos; our eta meson expert is LeRoy Price.

Mesons: Matts Roos and Paul Söding; our U. S. representative is A. H. Rosenfeld.

Baryons: A. Barbaro-Galtieri, Claude Bricman, and C. G. Wohl.

General: All of those at Berkeley cooperate on data processing, preparation of listings, tables, figures, text, etc., and programming and publication.

We enjoy and need your help in the form of suggestions, preprints, and the verification forms that you return. Please keep up this necessary communication.

II. SOME STATISTICS

We present here Fig. 1, which is an updated version of the same figure from the 1969 review, but we omit the discussion which accompanied it.

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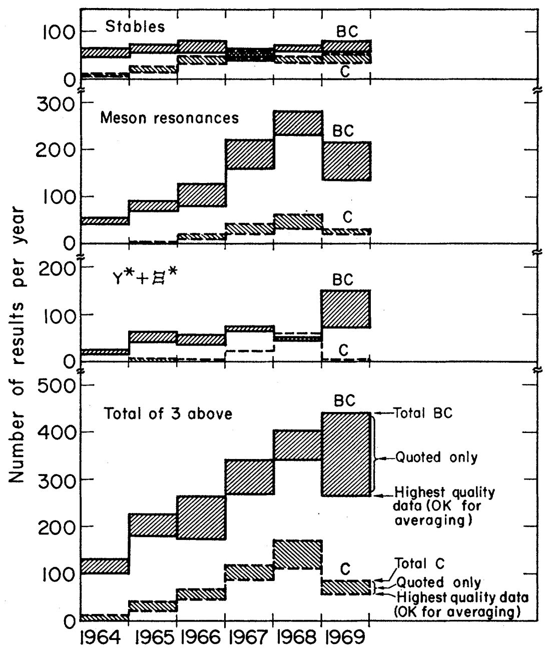

FIG. 1. Statistics on the increasing rate of production of data in particle physics. From the top to the bottom, the number of results per half-year are presented for stable particles, meson resonances, $Y^*+\Xi^*$'s, and the total of three above. The full lines correspond to bubble-chamber techniques (BC) and interrupted lines correspond to counters, spark chambers, and mass spectrometers (C). Within each topic (stables, meson resonances, etc.) and for both techniques (BC and C) the lower lines correspond to highest-quality data (accepted for averaging and fitting) and the upper lines correspond to all the results (including those which we only quote). The dashed areas give the number of nonaveraged results. Note that the figure omits N^* and Z^*, the field where counters have overwhelmed bubble chambers, because we punch mainly results from review articles instead of primary data.

The entries in Fig. 1 tend to rise from year to year, and a quick glance may suggest that they give cumulative counts. This is not so; we list entries per unit time, and the slope indicates only that our field is still growing. Naturally, the keenest competition between bubble chambers and "counters" is in experiments with stable particles. Bubble chambers provide almost all the information on mesons, but electronic devices and polarized targets have been needed to disentangle most of the N^*'s, as noted in the figure caption.

III. RETRIEVAL AND SELECTION OF DATA

Our procedures are as follows. We read journals and preprints and from information so obtained we punch data cards and reference cards for each relevant experiment. These cards are listed following the main text.

Computer programs make weighted averages of these data, and the results are summarized in three tables:

(i) Stable Particles, covers all particles which are immune to decay via the strong interaction.

(ii) Meson Resonances.

(iii) Baryon Resonances

Of course most of our work involves deciding how to handle data. Often it is best, in making weighted averages, to omit a given result. We have a provision for setting such data off in parentheses and we use it for the following reasons:

The quantity was presented with no error stated.

The result comes from a preprint or conference report and has not been verified by its authors.

It involves some assumptions that we do not wish to incorporate.

It is of poor quality, e.g., bad signal-to-noise ratio.

Two experiments give contradictory results, and more study is needed.

We then end up averaging only about one-half of our data cards.

When the data for a particle have received special treatment, this is noted in a "mini-review" in the data card listings.

IV. CRITERIA FOR "RESONANCES"

In 1969 we stated that we would not dismiss an *otherwise* convincing "resonance" just because it might have a possible nonresonant interpretation, usually a threshold enhancement. Thus we list the $A1$, Q, and L mesons, and warn that they may turn out to be just the appearance of a threshold enhanced by diffraction. Further warnings appear in the listings.

We take as the final test of a resonance the appearance of the Argand plot of the partial-wave amplitude. Thus the lowest-mass N^* bump seen in diffraction experiments like $pp\rightarrow N^*p$ is associated with the resonant behavior near 1470 MeV in the P_{11} π^-p partial wave. We list $N'(1470, \frac{1}{2}^+)$ as a resonance. On the other hand, the bump in $\sigma(K^+p)$ seen near $K\Delta$ threshold [the candidate for $Z_1(1915)$] is still not really confirmed by the Argand plots (although there are suggestions that the P_{13} amplitude, either Kp or $K\Delta$, may resonate somewhere). So we keep Z_1 down in our list of questionable candidates, omitted from the main table.

V. NOTES ON THE TABLES

A. General Notes

Quoted errors represent standard deviations. Inequalities are also standard deviations or $1/e$ confidence levels. In $I^G(J^P)C$ we have I=isotopic spin, J=spin, and P=parity. The others—G and C (or C_n)—are discussed in Sec. VII (Mesons). Well-established quantum numbers are underlined (except for stable particles, where most of the quantum numbers are established). We have used flimsy evidence to guess many of the remaining ones, and we have indicated with "?" the ones for which there is almost no evidence.

As is customary, we define antiparticles as the result of operating with CPT on particles, so both share the same spins, masses, and mean lives. Whenever there is a particularly interesting test of *CPT* invariance we include it in the Stable Particles table.

For resonances, Γ represents the full width at half-maximum, and "Mass" means that energy at which the resonant part of the amplitude reaches its maximum. Notice that even in the absence of problems with background, there are kinematical factors in the relations between cross section σ and amplitude T, so that one cannot expect that the peak in σ will be observed at the "Mass" that corresponds to the peak in $|T|^2$. For quantitative examples, see Barbaro-Galtieri (1968).

B. Fluctuations in Average Values Since the Preceding Edition

Any quantity which has changed by ≥ 1 (old) standard deviation from its tabulated value in January 1969 is italicized. Our motivation is twofold: (1) we are calling attention to poor procedures either on our part or on the part of the experimenters; (2) we suspect that quantities which have fluctuated unexpectedly in the past may continue to do so in the future. (We are not sure that this latter point is correct, but it seems reasonable. In particular we guess that there is a correlation between harder-than-average experiments and large fluctuations in the results.)

In our experience, the results most likely to cause trouble are those presented in papers hurriedly prepared for conferences. Even if the authors later stick by their central values, they often eventually revise their errors upwards. We list results from conferences and preprints in parentheses, but exclude them from averages until the authors specifically write to us to certify them.

VI. NOTES ON STABLE PARTICLES TABLE

Tabulation of both decay rates and branching fractions. Some theories will predict partial decay rates, others will predict branching fractions. In comparing such predictions with experimental results, one cannot get directly the errors in the rates from the errors in the fractions because of the correlated errors. This is especially true if the errors on the fractions are comparable with the uncertainty in the over-all decay rate, as in K decays. Then we tabulate *both* fractions and partial rates. A comparison with the $\Delta|I|=\frac{1}{2}$ rule for K decays is reported in Appendix I.

A. Muon-Decay Parameters

The μ-decay parameters describe the momentum spectrum (ρ and η), the asymmetry (ξ and δ), and the helicity (h) of the electron in the process $\mu^{\pm}\to e^{\pm}+\nu+\bar{\nu}$. Assuming a local and lepton-conserving interaction, the matrix element may be written as

$$\sum_i \langle \bar{e} \mid \Gamma_i \mid \mu\rangle\langle \bar{\nu} \mid \Gamma_i(C_i+C_i'\gamma_5) \mid \nu\rangle,$$

where the summation is taken over $i=S, V, T, A, P$. Using the definitions and sign conventions of Kinoshita and Sirlin (1957), we have

$$\rho=[3g_A^2+3g_V^2+6g_T^2]/D,$$

$$\eta=[g_S^2-g_P^2+2g_A^2-2g_V^2]/D,$$

$$\xi=[+6g_Sg_P\cos\phi_{SP}-8g_Ag_V\cos\phi_{AV}+14g_T^2\cos\phi_{TT}]/D,$$

$$\delta=[-6g_Ag_V\cos\phi_{AV}+6g_T^2\cos\phi_{TT}]/D\xi,$$

$$h=\pm[2g_Sg_P\cos\phi_{SP}-8g_Ag_V\cos\phi_{AV}-6g_T^2\cos\phi_{TT}]/D,$$

where

$$D=g_S^2+g_P^2+4g_A^2+4g_V^2+6g_T^2,$$

$$g_i^2=|C_i|^2+|C_i'|^2,$$

and

$$\cos\phi_{ij}=\text{Re}\,(C_i^*C_j'+C_i'C_j^*)/g_ig_j.$$

The quantities g_i are defined to be real positive numbers, and the ϕ_{ij} are phase angles between the i-type and j-type interactions. Under the assumption that $C_i'=-C_i$ and $C_j'=-C_j$ (two-component neutrinos), the S, P, and T terms vanish, and ϕ_{AV} is the phase angle between C_A and C_V in the complex plane.

By using the above equations and the experimental values of ρ, η, ξ, δ, and h we can place limits on g_S/g_V, g_A/g_V, g_T/g_V, g_P/g_V, and ϕ_{AV}. Note that most experiments study only the upper end of the spectrum where ρ and η are highly correlated, so they can only report ρ for $\eta\equiv0$ and η for $\rho\equiv\frac{3}{4}$. The values for ρ and η we use here were obtained by combining measurements of both upper and lower ends of the spectrum and are nearly uncorrelated.

We have defined a χ^2 which indicates how significantly ρ, η, ξ, δ, and h deviate from their experimental values ρ_0, η_0, ξ_0, δ_0, and h_0 in units of their experimental uncertainties σ_ρ, σ_η, σ_ξ, σ_δ, and σ_h:

$$\chi^2=[(\rho-\rho_0)^2/\sigma_\rho^2]+[(\eta-\eta_0)^2/\sigma_\eta^2]$$
$$+[(\xi-\xi_0)^2/\sigma_\xi^2]+[(\delta-\delta_0)^2/\sigma_\delta^2]+[(h-h_0)^2/\sigma_h^2].$$

The standard-error matrix techniques have not been used here because the χ^2 contours are far from elliptical in shape. For example, g_A/g_V vs ϕ_{AV} has a χ^2 contour which resembles the letter V, and the best-fit values are at the apex. Accordingly we have determined limits for g_S/g_V, g_A/g_V, g_T/g_V, g_P/g_V, and ϕ_{AV} as the largest and smallest values within the $\chi_{\min}^2+1$ hypersurface. The results, listed in the data cards, assume neither two-component neutrinos nor time-reversal invariance. If, however two-component neutrinos are assumed, then $\sin\phi_{AV}$ is the amplitude of time-reversal violation.

The radiative corrections are unambiguous only when $g_S=g_T=g_P=0$. The same limits on g_A/g_V and ϕ_{AV} are obtained, however, as when g_S, g_T, and g_P are left free.

B. K-Decay Parameters

CP violation in K^0 decays. Parameters of current interest are

$$\eta_{+-}=A(K_L\to\pi^+\pi^-)/A(K_S\to\pi^+\pi^-)$$
$$=|\eta_{+-}|\exp(i\phi_{+-}),$$
$$\eta_{00}=A(K_L\to\pi^0\pi^0)/A(K_S\to\pi^0\pi^0)$$
$$=|\eta_{00}|\exp(i\phi_{00}).$$

The phases ϕ_{+-} and ϕ_{00} have been measured directly, whereas the magnitudes $|\eta_{+-}|$ and $|\eta_{00}|$ are derived parameters. We have used, as far as we could, the directly measured quantities as input and have calculated $|\eta_{+-}|$ and $|\eta_{00}|$ from the values given by our constrained fits. Therefore, if one looks at the data card listings, most of the $|\eta|$ measurements appear in the form of branching ratios, with appropriate comments.

$\Delta S=\Delta Q$ rule in K^0 decays. The validity of this rule is measured by the parameter x, defined as

$$x=A(\bar{K}^0\to\pi^-l^+\nu)/A(K^0\to\pi^-l^+\nu).$$

We list Re x and Im x.

Form Factors in K_{l3} Leptonic Decays

Assuming that only the vector current contributes to these decays, we write the matrix element as

$$\langle\pi|J_\lambda|K\rangle\propto[f_+(q^2)(P_K+P_\pi)_\lambda+f_-(q^2)(P_K-P_\pi)_\lambda],$$

where P_K and P_π are the four momenta of K and π mesons; f_+ and f_- are dimensionless form factors which can depend only on $q^2=(P_K-P_\pi)^2$, the square of the momentum transfer to the leptons. The parameters we list are $\lambda_\pm$, the energy dependence of the $f_\pm(q^2)$ form factor,

$$f_\pm(q^2)=f_\pm(0)[1+\lambda_\pm(q/m_\pi)^2];$$

and ξ, the ratio of the two form factors,

$$\xi=f_-/f_+.$$

The quantity ξ can be determined in different ways:

(1) by measuring the $K_{\mu3}/K_{e3}$ branching ratio and comparing it with the theoretical ratio as given in terms of $\xi(0)=f_-(0)/f_+(0)$:

$$\Gamma(K_{\mu3})/\Gamma(K_{e3})=0.6487+0.1269\text{ Re }\xi+0.0193|\xi|^2$$
$$+1.390\lambda_++0.476\lambda_-\text{ Re }\xi$$

(see CABIBBO 66 in K^+ card listings).

(2) by measuring the π or lepton momentum spectra and comparing them with the predicted spectra, which are functions of ξ (see, for example, BRENE 61 in the K^+ card listings).

(3) by measuring the muon polarization in $K_{\mu3}$ decay. In the rest frame of the K the μ is expected to be polarized in the direction $\mathbf{A}$ with $\mathbf{P}=\mathbf{A}/|\mathbf{A}|$, where $\mathbf{A}$ is given (CABIBBO 64 in K^+ card listings) by

$$\mathbf{A}=a_1(\xi)\mathbf{p}_\mu-a_2(\xi)\{(\mathbf{p}_\mu/m_\mu)[(m_k-E_\pi)$$
$$+(\mathbf{p}_\pi\cdot\mathbf{p}_\mu)(E_\mu-m_\mu)/|\mathbf{p}_\mu|^2)]+\mathbf{p}_\pi\}$$
$$+m_K\text{ Im }\xi(q^2)(\mathbf{p}_\pi\times\mathbf{p}_\mu).$$

If time-reversal invariance holds, we expect ξ to be real, and thus expect no polarization perpendicular to the K-decay plane. See the note in the listing, after K^+ decays, for discussions of experimental results.

C. Baryon-Decay Parameters

A/V ratio for baryon leptonic decays. The baryon part of the matrix element for these decays may be written as

$$\langle B_f|\gamma_\lambda(g_V-g_A\gamma_5)|B_i\rangle,$$

where B_i and B_f represent initial and final baryons, and g_A and g_V the axial and vector coupling constants. Here the Pauli metric is used for the γ matrices. The definition of g_A/g_V is

$$g_A/g_V=|g_A/g_V|e^{i\delta},$$

where δ is expected to be $0+n\pi$ if time-reversal invariance holds (see JACKSON 57 in neutron card listings).

In neutron beta decay the measurements are consistent with time reversal, so g_A/g_V therefore is nearly real and has been considered to be such in all the baryon leptonic decays. Notice that by using the above definition of the matrix element with the Pauli metric, the value of g_A/g_V in neutron beta decay is negative.

We compile the ratio g_A/g_V with its sign, for those decays for which it has been measured. For the neutron beta decay we compile also the phase δ.

Asymmetry parameters in nonleptonic hyperon decays. The transition matrix for the hyperon decay may be written as

$$M=s+p(\boldsymbol{\sigma}\cdot\mathbf{q}), \qquad (1)$$

where s and p are the parity-changing and the parity-conserving amplitudes, respectively, $\boldsymbol{\sigma}$ is the Pauli spin operator, and $\mathbf{q}$ is a unit vector along the direction of the decay baryon in the hyperon rest frame.

The asymmetry parameters are defined by the relations

$$\alpha=2\text{ Re }(s^*p)/(|s|^2+|p|^2),$$
$$\beta=2\text{ Im }(s^*p)/(|s|^2+|p|^2),$$
$$\gamma=(|s|^2-|p|^2)/(|s|^2+|p|^2).$$

With the transition matrix (1), the angular distribution of the decay baryon, in the hyperon rest system, is of the form

$$I=1+\alpha\mathbf{P}_Y\cdot\mathbf{q},$$

where $\mathbf{P}_Y=\langle Y|\boldsymbol{\sigma}|Y\rangle$ is the hyperon polarization.

The polarization $\mathbf{P}_B$ of the decay baryon is[1]

$$\mathbf{P}_B=\frac{(\alpha+\mathbf{P}_Y\cdot\mathbf{q})\mathbf{q}+\beta(\mathbf{P}_Y\times\mathbf{q})+\gamma\mathbf{q}\times(\mathbf{P}_Y\times\mathbf{q})}{1+\alpha\mathbf{P}_Y\cdot\mathbf{q}},$$

where $\mathbf{P}_B$ is defined in that rest system of the baryon obtained by a Lorentz transformation along $\mathbf{q}$ from the hyperon rest system in which $\mathbf{q}$ and $\mathbf{P}_Y$ are defined. Note that α is the helicity of the decay baryon for unpolarized hyperons.

The three parameters α, β, and γ satisfy the relation

$$\alpha^2+\beta^2+\gamma^2=1.$$

It is then convenient to describe hyperon nonleptonic decays in terms of the two independent parameters α and the angle ϕ defined by

$$\beta=(1-\alpha^2)^{1/2}\sin\phi,$$
$$\gamma=(1-\alpha^2)^{1/2}\cos\phi,$$

which has a more nearly Gaussian distribution than β or γ. Evidently

$$-\tfrac{1}{2}\pi\leq\phi\leq\tfrac{1}{2}\pi \quad \text{for} \quad \gamma>0,$$
$$+\tfrac{1}{2}\pi\leq\phi\leq\tfrac{3}{2}\pi \quad \text{for} \quad \gamma<0.$$

In discussing time-reversal invariance, the quantity of interest is Δ, defined by

$$\alpha=2\,|s|\,|p|\cos\Delta/(|s|^2+|p|^2),$$
$$\beta=-2\,|s|\,|p|\sin\Delta/(|s|^2+|p|^2);$$

that is, Δ is the phase angle of s relative to p. Evidently

$$-\tfrac{1}{2}\pi\leq\Delta\leq\tfrac{1}{2}\pi \quad \text{for} \quad \alpha>0,$$
$$+\tfrac{1}{2}\pi\leq\Delta\leq\tfrac{3}{2}\pi \quad \text{for} \quad \alpha<0.$$

Under the assumption of time-reversal invariance, the angle Δ must satisfy the relation

$$\Delta=\delta_s-\delta_p,$$

modulo π, where δ_s and δ_p are the pion–baryon scattering phase shifts at the appropriate energy and for the appropriate isospin state. For Λ decay, assuming the validity of the $|\Delta I|=\frac{1}{2}$ rule,

$$\Delta=\delta_s-\delta_p=(6.8\pm2.0)\text{ deg.}^2$$

On the data cards we list α and ϕ for each decay since they are the most closely related to the experiments and are essentially uncorrelated. Whenever necessary we have changed the signs of the reported values, so as to agree with our conventions. In the Stable Particles table we give α, ϕ, and Δ with errors; and for convenience we also give the central value of γ, without an error.

[1] Lee and Yang (1957). Note that this paper contains a misprint. The minus sign in the definition of β should be replaced by a 2. In addition, our unit vector $\mathbf{q}$ is the direction of the baryon, whereas their unit vector $\mathbf{p}$ is the direction of the pion.

[2] This value for $\delta_s-\delta_p$ is derived from the phase-shift analyses by L. D. Roper, R. M. Wright, and B. T. Feld, Phys. Rev. **138**, B190 (1965). The error is our estimation of the uncertainty.

VII. NOTES ON THE MESON TABLE

A. The Symbol-Minded Approach

If a meson has a well-accepted colloquial name, we use it. If not, we name it by a single symbol which specifies its atomic mass number A $(=0$ for mesons), its hypercharge Y, its isospin I, and, for a nonstrange meson, its G parity [see Eqs. (2) and (3)]. We choose

$I=0$; η if G is even, ϕ if it is odd

$I=1$; ρ if G is even, π if it is odd

$I=\frac{1}{2}$; K

$I=\frac{3}{2}$; (if ever established) L.

To crowd even more information onto the symbol, we add a subscript giving J^P. Thus $\eta_{0+}(1070)$. If J^P is not known, but must be "normal" $(0^+, 1^-, 2^+, \cdots)$, e.g., because $K\pi$ decays are seen, we use the subscript N. Thus $K_N(1420)$. If such modes are *not* seen [and are not otherwise forbidden, e.g., by Eq. (5) below], we *guess* that it is because J is abnormal, and we write, for example, $K_A(1320)$.

When two states have identical quantum numbers, we add a "prime" to the heavier, e.g., η, η'; f, f' [and for baryons we write, N, N' $(1470, \frac{1}{2}^+)$].

B. G Parity and the Shorthand C_n

The charge conjugation operator C turns particle into antiparticle and has eigenvalues ±1 only for neutral states; so it is useful to define an extension G which has eigenvalues for charged states too. It is usually[3] defined by

$$G=C\exp(i\pi I_y). \tag{2}$$

A neutral nonstrange state is an eigenstate of $\exp(i\pi I_y)$ with eigenvalue $(-1)^I$. Then we can write the eigenvalue equation for the whole multiplet as

$$G=C_n(-1)^I, \tag{3}$$

where C_n (n for neutral) is the eigenvalue C would have if applied to the neutral member of the multiplet. Thus, for a π^0, C has the eigenvalue $+1$, and since $I=1$, $G=-1$. For the charged pion there are no eigenvalues corresponding to C and to the isospin rotation, but Eqs. (2) and (3) still give $G=-1$.

C. C, P, G for Meson↔Particle–Antiparticle (e.g., $\pi\pi$, $K\bar{K}$, $p\bar{p}$, or Quark–Antiquark)

Many of our quantum-number assignments are based on Eqs. (4) and (5) below. These same equations also apply for the quark model; their meaning is as follows. Consider a meson as a bound state of fermion–antifermion, e.g., $\bar{q}q$, with orbital angular momentum l,

[3] Most texts define it as in Eq. (2); see, e.g., Gasiorowicz (1966); however, sometimes the rotation is taken about I_x. The difference between the two conventions is mentioned in a footnote in Källén (1964).

TABLE I. $I^G(J^P)$ of mesons from $\bar{q}q$ model. For the distinction between "abnormal J^P" and "abnormal C," see text. $I=\frac{1}{2}$ states share the same values of J^P as the $I=0$ and 1 states shown, but are not eigenstates of G. The middle column, which gathers together $(J^P)_{N \text{ or } A}CP$ is a redundant intermediate step intended to make the table easier to read.

Parity	$\bar{q}q$ State CP −	$\bar{q}q$ State CP +	(J^P) CP (Normal or abnormal)	$I^G(J^P)C_n$	Examples and comments
Parity −	$^1S_0$		$(0^-)_A{}^-$	$0^+(0^-)+$ $1^-(0^-)+$	η, η' π
		$^3S_1$	$(1^-)_N{}^+$	$0^-(1^-)-$ $1^+(1^-)-$	ω, ϕ ρ
Parity +	$^1P_1$		$(1^+)_A{}^-$	$0^-(1^+)-$ $1^+(1^+)-$	B
		$^3P_0$	$(0^+)_N{}^+$	$0^+(0^+)+$ $1^-(0^+)+$	$\eta_{0^+}(1060)$ $\pi_N(1016)$
		$^3P_1$	$(1^+)_A{}^+$	$0^+(1^+)+$ $1^-(1^+)+$	 A1
		$^3P_2$	$(2^+)_N{}^+$	$0^+(2^+)+$ $1^-(2^+)+$	f, f' A2
Parity −	$^1D_2$		$(2^-)_A{}^-$	$0^-(2^-)+$ $1^+(2^-)+$	Regge recurrence of $^1S_0$, 0^-
		$^3D_1$	$(1^-)_N{}^+$	same as $^3S_1$	
		$^3D_2$	$(2^-)_A{}^+$	$0^-(2^-)-$ $1^+(2^-)-$	Regge recurrence of top abnormal-C state below: $(J^P)C_n = (0^-)-$
		$^3D_3$	$(3^-)_N{}^+$	$J > 2$	
Parity +	$^1F_3$		$(3^+)_A{}^-$	$J > 2$	
		$^3F_2$	$(2^+)_N{}^+$	same as $^3P_2$	Another A2?
		$^3F_3$	$(3^+)_A{}^+$	$J > 2$	
		$^3F_4$	$(4^+)_N{}^+$	etc.	

ABNORMAL C STATES THAT CANNOT COME FROM $\bar{q}q$ MODEL

Abnormal C states Have no $\bar{q}q$ model	$(0^-)_A{}^+$	$0^-(0^-)-$ $1^+(0^-)-$	All except $J^P = 0^-$ are J^P = normal, CP = −1
	$(1^-)_N{}^-$	$0^+(1^-)+$ $1^-(1^-)+$	
	$(0^+)_N{}^-$	$0^-(0^+)-$ $1^+(0^+)-$	
	$(2^+)_N{}^-$	$0^-(2^+)-$ $1^+(2^+)-$	
	$(3^-)_N{}^-$	$0^+(3^-)+$ $1^-(3^-)+$	

and with the two quark spins coupling to give a spin S. Then one can show that the charge-conjugation eigenvalue [defined in Eq. (3)] is

$$C_n = (-1)^{l+S}. \tag{4}$$

Eqs. (3) and (4) combine to give

$$G = (-1)^{l+S+I}. \tag{5}$$

The parity is

$$P = -(-1)^l \tag{6}$$

Equations (4) and (6) combine to give

$$C_n P = -(-1)^S$$

so all singlets ($^1S_0$, $^1P_1$, $\cdots$) have $C_nP = -1$, and all triplets ($^3S_0$, $\cdots$) have $C_nP = +1$.

If, instead of $\bar{q}q$, we consider the meson as a state of *boson–antiboson* (e.g., $A2 \to \bar{K}K$), it turns out that some signs cancel, and Eqs. (4) and (5) [not (6)] apply *unchanged*. Of course the mesons are usually spinless and S is zero, but the equations are more general. Equations (4) and (5) can be considered as selection rules forbidding many decays.

For proofs see our 1969 text, and Appendix by C. Zemach. We repeat here the summary Table I, which we used in 1969 as Table II.

VIII. NOTES ON THE BARYON TABLE

Just as we did for mesons, we identify baryon states by a single symbol which specifies atomic number ($A = 1$), hypercharge Y, and isospin I, but for baryons no attempt has been made to attach a subscript about J and P. The symbols are

Z_I	for	$Y=2$,	$I=0, 1$;
N	for	$Y=1$,	$I=\frac{1}{2}$;
Δ	for	$Y=1$,	$I=\frac{3}{2}$;
Λ	for	$Y=0$,	$I=0$;
Σ	for	$Y=0$,	$I=1$;
Ξ	for	$Y=-1$,	$I=\frac{1}{2}$;
Ω	for	$Y=-2$,	$I=0$.

For the lowest-mass state of each Y and I we use the symbol standing alone; for the heavier states, the mass is in parentheses [i.e., $N(1688)$, $\Lambda(1405)$, $\Sigma(1765)$, etc.]. The J^P assignment is reported in the table as $\frac{1}{2}^+$, $\frac{3}{2}^-$, $\frac{5}{2}^+$, etc., and also by the symbols P_{11}, D_{13}, F_{15}, which refer to the partial-wave amplitude where the resonant state occurs (the first subscript refers to the isospin state).

Most of the useful information on the N, Δ, Λ, and Σ with $M < 2000$ MeV has come from partial-wave analysis. Masses and widths of most of these states are dependent on the data and on the model used by the different groups that performed these analyses; therefore the tabulated masses are not averages, but plausible guesses, and the errors are "external errors" based on the consistency among different analyses. For the procedures adopted, different from resonance to resonance, see the appropriate mini-review in the data card listings.

Resonances with mass $M > 2000$ MeV have been detected primarily in total-cross-section experiments. Any bump in the total cross section of size σ_{res} at the value of the resonant mass gives information on the elasticity x_e and the J assignment of the resonance through the expression

$$\sigma_{\text{res(total)}} = 4\pi\lambda\!\!\!^{-2}(J+\tfrac{1}{2})x_e.$$

If J and x_e are not separately known, the product $(J+\frac{1}{2})x_e$ for the resonance is given in the baryon table.

IX. PROCEDURES FOR TREATING THE DATA

This discussion is divided into two main topics: (A) Problems of inconsistent experiments, which cause us to introduce ideograms and scale factors, and (B) Procedures for constrained fits, where of course inconsistent data cause some extra complications.

In the absence of constraints, we can simply calculate a weighted average

$$\bar{x} \pm \delta\bar{x} = (\sum w_i x_i / \sum w_i) \pm [1/(\sum w_i)^{1/2}];$$
$$w_i = [1/(\delta x_i)^2], \tag{7}$$

where the sums run over N experiments. We also calculate χ^2 and compare it with its expectation value of $N-1$.

A. Inconsistent Data

If χ^2 is larger than $N-1$, but not ridiculously so, we still average the data, and then try to make up for this perhaps unwarranted procedure in two ways:

1. Ideograms

We plot an ideogram to guide the reader in deciding which data he might reject before making his own selected average. Previously each experiment ideogrammed was assigned the same area, but this year we have decided that for the purposes of visual display it is perhaps more meaningful to weight each experiment by $1/\delta x_i$, i.e., by the inverse of its error. We base this weight on the assumption that an experimenter will work to reduce his systematic errors until they are slightly smaller (but seldom much smaller) than his statistical errors. Thus as a bubble-chamber physicist gets more events, he will use them both to reduce his statistical errors and to study his biases. Our confidence that a significant systematic error has not been made in his experiment, as compared with other contradictory experiments, then tends to go up as $1/\delta x_i$.

But why not assign a weight $1/\delta x_i^2$, as is done when computing a weighted average? We feel that this is

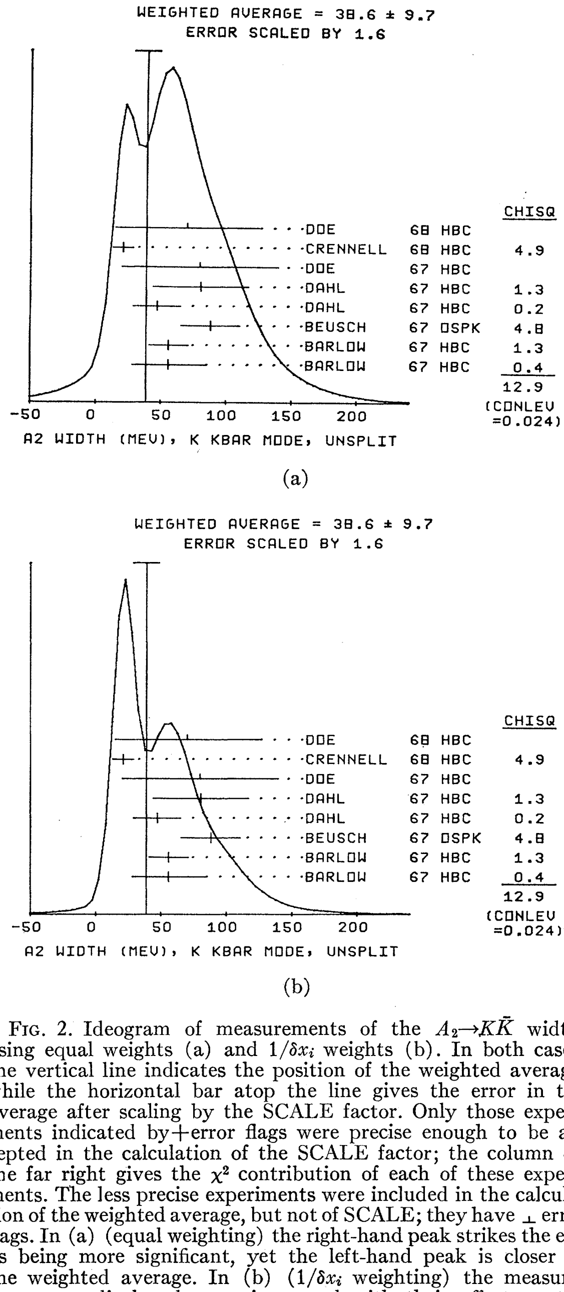

FIG. 2. Ideogram of measurements of the $A_2 \to K\bar{K}$ width, using equal weights (a) and $1/\delta x_i$ weights (b). In both cases, the vertical line indicates the position of the weighted average, while the horizontal bar atop the line gives the error in the average after scaling by the SCALE factor. Only those experiments indicated by + error flags were precise enough to be accepted in the calculation of the SCALE factor; the column on the far right gives the χ^2 contribution of each of these experiments. The less precise experiments were included in the calculation of the weighted average, but not of SCALE; they have ⊥ error flags. In (a) (equal weighting) the right-hand peak strikes the eye as being more significant, yet the left-hand peak is closer to the weighted average. In (b) ($1/\delta x_i$ weighting) the measurements are displayed more in accord with their effect on the weighted average. We do not use $1/\delta x_i^2$ weights for the ideogram, as that would make the unreasonable assumption that large systematic errors are as infrequent as large statistical fluctuations. See text.

equivalent to assuming that large systematic errors are as infrequent as large statistical fluctuations, and that this is unrealistic.

Figure 2 shows ideograms prepared both the old (equal area) and the new ($1/\delta x_i$) way. We feel that the new way gives a more reasonable appearance.

We want to emphasize the difference between least-squares averaging (where the weighting factor is the inverse square of the error) and the ideograms prepared for visual display. The former arithmetic is of course best if one has statistically distributed input, and yields a narrow Gaussian distribution centered at the weighted mean. The ideogram (often multipeaked and certainly not Gaussian) is based on the opposite hypothesis that some of the input is systematically in error. The idea behind least-squares averaging is that experiments 1, 2, 3, etc., are *all* valid (so we should multiply their probabilities); our *ideograms* are based on the assumption that 1 *or* 2 *or* 3, etc., is valid, "hedged" with $1/\delta x_i$ betting odds; we then add their probabilities. Both approaches cannot simultaneously be right; we leave it to the reader to choose. A glance at the ideogram will show, however, that the discrepancy is often not severe for reasonably distributed input.

2. *SCALE Factor*

If $\chi^2 > N-1$, we increase the error $\delta\bar{x}$ in Eq. (7) by a factor

$$\text{SCALE} = [\chi^2/(N-1)]^{1/2}. \quad (8)$$

Our reasoning is as follows. Since we don't know which one or more of the experiments are wrong, we assume that all experimentalists underestimated their errors by the same scale factor (8). If we scale up all input errors by this factor, χ^2 returns to $N-1$, and of course the output error scales up by the same factor.

If all the experiments have errors of about the same size, the above (straightforward) procedure for calculating SCALE is carried out. If, however, we are to combine experiments with widely varying errors, we must modify the procedure slightly. This is because it is the more precise experiments that most influence not only the average value $\bar{x}$, but also the error $\delta\bar{x}$. Now, on the average, the low-precision experiments each contribute about unity to *both* the numerator and the denominator of SCALE, hence the χ^2 contribution of the sensitive experiments is diluted, i.e., reduced. Therefore, we evaluate SCALE by using *only* experiments for which the errors are not much greater than those of the more precise experiments. Explicitly, to calculate SCALE we use only the most sensitive experiments, i.e., those with errors less than δ_0, where the ceiling δ_0 is (arbitrarily) chosen to be

$$\delta_0 = 3N^{1/2}\delta\bar{x}.$$

Here $\delta\bar{x}$ is the unscaled error of the mean of all the experiments. Note that if each experiment had the same error δx_i, then $\delta\bar{x}$ would be $\delta x_i/N^{1/2}$, so each individual experiment would be well under the ceiling on SCALE.

This scaling approach has the property that if there are two values with comparable errors separated by much more than their stated errors (with or without a number of other experiments of lower accuracy), the error on the mean value $\delta\bar{x}$ is increased so that it is approximately half the interval between the two discrepant values.

We wish to emphasize the fact that our scaling procedures for *errors* in no way affect central values. In addition, if one wishes to recover the unscaled error $\delta\bar{x}$, he need only divide the given error by the SCALE factor for that error.

B. Constrained Fits

Except for trivial cases, all branching ratios and rate measurements are analyzed by computer program AHR. This program makes a simultaneous least-squares fit to all the data, and outputs the partial-decay fractions $\bar{P}_i$, width Γ, partial widths $\bar{W}_i$, and their error matrix.

The original version of AHR was written by J. Peter Berge. It is documented separately, and we wish here only to give the simplest nontrivial example that permits us to comment on the error matrix and the scale factor.

Assume that a state has only three partial-decay fractions, P_1, P_2, and P_3 ($\sum P_i=1$), which have been measured in four different ratios, $R_1, \cdots, R_4$, where, e.g., $R_1=P_1/P_2$, $R_2=P_1/P_3$, etc.[4] Further assume that *each* ratio has been measured by N experiments (we designate each experiment with a subscript x, e.g., R_{1x}). Then AHR finds the best values of P_1, P_2, and P_3 by minimizing χ^2, namely

$$\chi^2=\sum_{r=1}^{4}\left[\sum_{x=1}^{N}\left(\frac{R_{rx}-R_r(P_1,P_2,P_3)}{\delta R_{rx}}\right)^2\right]. \qquad (9)$$

In addition to the fitted values $\bar{P}_i$, the program calculates an error matrix $\langle\delta\bar{P}_i\delta\bar{P}_j\rangle$. We tabulate the diagonal elements $\delta\bar{P}_i=\langle\delta\bar{P}_i\delta\bar{P}_i\rangle^{1/2}$ [except that some errors are scaled according to Eq. (8) as discussed below]. In the listings we give the complete error matrix; we also calculate the fitted value of each ratio, for comparison with the input data, and list it below the relevant input, along with a simple unconstrained average of the same input.

Two further comments on the example above:

(1) There was no connection between measurements of the width and the branching ratios. But often we also have information on partial widths W_i as well as total width Γ (both are coded on the data cards as W for width). In this case AHR must introduce Γ as a parameter into the fit, along with the relations $\Gamma_i=\Gamma P_i$, $\sum\Gamma_i=\Gamma$. When appropriate, we tabulate the Γ_i along with the P_i, and give error matrices in the listings.

(2) Note that we do *not* allow for correlations between input data. We *do* try to pick those ratios and widths which are as independent and as close to the original data as possible.

When *inequalities* are reported, on the first iteration we ignore them; we then check to see if the weighted average of the other data violates the inequality. If an upper limit is violated, we change the input data: $<x\rightarrow 0\pm x$. If a lower limit is violated, one cannot always invoke such a simple prescription, and each case must be handled individually.

In *asymmetric* errors, we use a continuous function of $\delta(P)^+$ and $\delta(P)^-$ in the fitting. When no errors are reported, we merely list the data for inspection.

Hyperon-Decay Parameters

The program AHR handles any type of input, α, Φ, Δ, β, or γ, according to the definitions of Sec. VI. If for a particular hyperon decay there are data for more than two of the decay parameters, they are analyzed by using the constraint

$$\alpha^2+\beta^2+\gamma^2=1.$$

Inconsistent Constrained Data

According to our simple example, which led to Eq. (9), the double sum for χ^2 is summed over experiments $x=1$ to N, leaving a single sum over ratios

$$\chi^2=\sum_r \chi_r^2.$$

Even before fitting, some of the χ_r^2 may be too large. But if we scaled them before fitting, then the scaling would move the central value, contrary to our policy. So we do not scale until after the first fit; then, knowing the fitted χ_r^2 and its expectation value $\langle\chi_r^2\rangle$ we form SCALE factors (just as before), i.e.,

$$(\text{SCALE})_r^2=\chi_r^2/\langle\chi_r^2\rangle,$$

and if any $(\text{SCALE})_r$ is greater than ≈ 1, all N of the measurements of that particular ratio are equally penalized by having their errors increased by SCALE. Program AHR then recycles on all the data, those with errors unchanged as well as those with errors increased. We then get new values, $\delta\bar{P}_i'$ for the errors in the partial decay modes.

Because of the constraint ($\sum P_i=1$) some SCALE factors may still be greater than ≈ 1 even after this second pass. If this is so, the whole procedure (i.e., increasing errors by the new SCALE factors and recycling through AHR) is repeated.

At the end of AHR's final pass we have *two* measures of the errors for the $\bar{P}_i$. One is, of course, the $\delta\bar{P}_i'$, i.e., the errors in the final fitted values $\bar{P}_i'$ which include the effects of scaling the input errors. The other measure of the errors is $(\bar{P}_i-\bar{P}_i')$, i.e., the *shift* in the central values of the ith mode between the first (unscaled) fit and the final (scaled) fit. In practice we find that on the average these two measures of the uncertainty are about equal. Rather than selecting just one or the other, our

[4] We can handle any R of the form

$$R=\Sigma\alpha_i P_i/\Sigma\beta_i P_i',$$

where α_i and β_i are constants, usually 1 or 0.

tabulated errors are given by the combination

$$(\delta\bar{P}_i)_{\text{tab}} = [\delta\bar{P}_i'^2 + (\bar{P}_i - \bar{P}_i')^2]^{1/2},$$

where $\bar{P}_i$ is the fitted value of the ith partial-decay mode before scaling, $\bar{P}_i'$ is its value after scaling, and $\delta\bar{P}_i'$ is the error in $\bar{P}_i'$. The SCALE factors we finally list in such cases are defined by

$$(\text{SCALE})_i = (\delta\bar{P}_i)_{\text{tab}}/\delta\bar{P}_i.$$

However, in line with our policy of not letting SCALE affect the central values, we give the values of $\bar{P}_i$ obtained from the original (unscaled) fits. [The differences between the $\bar{P}_i$ calculated with either the scaled or the unscaled errors are, of course, always within the tabulated errors, $(\delta\bar{P}_i)_{\text{tab}}$.]

X. NOTES ON THE DATA CARD LISTINGS

A guide to the use of the data card listings can be found in an illustrated key, immediately preceding the listings, which follow the tables.

In the baryon listings, starting this time, we have separated formation (i.e., s-channel) experiments from production experiments. Our motivation is as follows: We now know that often several baryon resonances have the same mass and can be separated only by a partial-wave analysis in the s channel. In this case we do not want the production experiments to contaminate the formation experiments. Conversely, $\Sigma(1385)$ and $\Lambda(1405)$, which lie below $\bar{K}N$ threshold, can be seen directly in production experiments, but only via uncertain extrapolations from the s channel. Again we want to keep the results separate. Since the baryon resonance parameters M and Γ are not averages, but are estimates based on the consistency of several experiments of a single type, we conclude that it is best to separate formation and production experiments.

In 1966 we removed some of the obsolete data and references. They may be found in our earlier editions, e.g., Rosenfeld *et al.* (1965).

XI. WALLET SHEETS, DATA BOOKLETS, AND APPOINTMENT BOOKLETS

In past editions we have included up to four wallet sheets, printed on thin durable "wallet proof" paper. But we have now decided to de-emphasize them in favor of the more popular 3 in.×5 in. data booklets. We intend in the future to put on the sheets only the tables of particle properties plus occasional new or modified tables. In this edition we have included a corrected version of the SU_3 Isoscalar Table, corrected to conform with the accepted convention for the sign of F/D.

Data booklets, however, are so hard to make copies of that we have decided to print the rest of the useful tables therein as Appendix II to this review.

Extra copies are available, from CERN and LRL, of the wallet sheets and the following pocket sized (3 in.×5 in.) items: the data booklet, a 1970 diary, a mini-atlas, a plastic cover. We occasionally receive requests for multiple copies or copies for classroom use; we can supply the wallet sheets free, but must charge 10¢ for each of the pocket-sized items.

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Odette Benary has helped us, particularly with the data booklet; Stanley J. Brodsky has been our consultant on fundamental constants. David Herndon has collected results of πN and $\bar{K}N$ partial-wave analyses, and written the programs which display their Argand diagrams, speed plots, etc. Arlene Wells has helped with the data handling. H. Baisch has assisted with the meson data. We thank J. D. Jackson and F. T. Solmitz for useful comments.

BIBLIOGRAPHY

A. Barbaro-Galtieri, "Baryon Resonances," in *Advances in Particle Physics,* R. L. Cool and R. E. Marshak, Eds. (John Wiley & Sons., Inc., New York, 1968), Vol. 2. See specifically, Table IV and Figs. 10 and 12.
S. Gasiorowicz, *Elementary Particle Physics* (John Wiley & Sons, Inc., New York, 1966).
G. Källén, *Elementary Particle Physics* (Addison–Wesley Publ. Co., Reading, Mass., 1964).
T. Kinoshita and A. Sirlin, Phys. Rev. **108,** 844 (1957).
T. D. Lee and C. N. Yang, Phys. Rev. **108,** 1645 (1957).
Particle Data Group: N. Barash-Schmidt, A. Barbaro-Galtieri, L. R. Price, A. H. Rosenfeld, P. Söding, C. G. Wohl, M. Roos, and G. Conforto, Rev. Mod. Phys. **41,** 109 (1969).
A. H. Rosenfeld, A. Barbaro-Galtieri, W. H. Barkas, P. L. Bastien, J. Kirz, and M. Roos, Rev. Mod. Phys. **37,** 633 (1965).

PARTICLE PROPERTIES: January 1970

From Review of Particle Properties, UCRL-8030.

N. Barash-Schmidt, A. Barbaro-Galtieri, C. Bricman, S. E. Derenzo, L. R. Price, A. Rittenberg, Matts Roos, A. H. Rosenfeld, Paul Söding, and C. G. Wohl

(Closing date for data: November 1, 1969)

STABLE PARTICLES: January 1970

Quantities in italics have changed by more than one (old) standard deviation since January 1969.

	$I^G(J^P)C$	Mass (MeV) / Mass² (GeV)²	Mean life (sec) / $c\tau$(cm)	Decays: Partial mode	Decays: Fraction[a]	p or p_{max} (MeV/c)[b]
γ	$0,1(1^-)^-$	$0(<2.)10^{-21}$	stable	stable		
ν	ν_e $J=\frac{1}{2}$	0(<60 eV)	stable	stable		
	ν_μ	0(<1.6)				
e	$J=\frac{1}{2}$	0.511006	stable	stable		
		±.000002	$(>2\times10^{21}y)$			
μ	$J=\frac{1}{2}$	105.659	2.1983×10^{-6}	$e\nu\bar{\nu}$	100	53
		±.002	±.0008	$e\gamma\gamma$	(<1.6)10^{-5}	53
		$m^2=$ 0.0112	$c\tau=6.592\times10^4$	3e	(<1.3)10^{-7}	53
		$m_\mu-m_{\pi^\pm}=-33.920$		$e\gamma$	(<2)10^{-8}	53
		±.013				
$\pi^\pm$	$1^-(0^-)$	139.578	2.603×10^{-8}	$\mu\nu$	100 %	30
		±.013	±.006, S=2.0*	$e\nu$	(1.24±0.03)10^{-4}	70
		$m^2=$ 0.0195	$c\tau=781$	$\mu\nu\gamma$	c(1.24±0.25)10^{-4}	30
		$(\tau^+-\tau^-)/\bar{\tau}$ =	(0.05±0.07)%	$\pi^0e\nu$	(1.02±0.07)10^{-8}	5
			(test of CPT)	$e\nu\gamma$	c(3.0 ±0.5)10^{-8}	70
π^0	$1^-(0^-)^+$	134.975	0.89×10^{-16}	$\gamma\gamma$	(98.83±0.04)%	67
			±.18, S=1.6*	γe^+e^-	(1.17±0.04)%	67
		$m^2=$ 0.0177	$c\tau=2.67\times10^{-6}$	$\gamma\gamma\gamma$	(<5)10^{-6}	67
		$m_{\pi^\pm}-m_{\pi^0}$ = 4.6041		$e^+e^-e^+e^-$	d(3.47)10^{-5}	67
		±.0037				
$K^\pm$	$\frac{1}{2}(0^-)$	493.82	1.235×10^{-8}	$\mu\nu$	(63.77±0.29)% S=1.1*	236
		±0.11	±.004 S=1.8*	$\pi\pi^0$	(20.93±0.30)% S=1.2*	205
		$m^2=$ 0.244	$c\tau=370$	$\pi\pi^-\pi^+$	(5.57±0.04)% S=1.2*	126
		$(\tau^+-\tau^-)/\bar{\tau}$ =	(.09±.12)%	$\pi\pi^0\pi^0$	(1.70±0.05)%	133
			(test of CPT)	$\mu\pi^0\nu$	(3.18±0.11)% S=2.0*	215
			S=1.3*	$e\pi^0\nu$	(4.85±0.07)% S=1.2*	228
		$m_{K^\pm}-m_{K^0}=-3.94$		$\pi\pi^\mp e^\pm\nu$	(3.3 ±0.3)10^{-5}	203
		± 0.13		$\pi\pi^\pm e^\mp\nu$	(<7)10^{-7}	203
				$\pi\pi^\mp\mu^\pm\nu$	(0.9 ±0.4)10^{-5}	151
				$\pi\pi^\pm\mu^\mp\nu$	(<3)10^{-6}	151
				$e\nu$	(1.2 ±0.3)10^{-5}	247
				$\pi\pi^0\gamma$	c(<1.9)10^{-4}	205
				$\pi\pi^+\pi^-\gamma$	c(10 ±4)10^{-5}	126
				$\pi e\nu\gamma$	c(6 ±4)10^{-4}	227
				πe^+e^-	(<0.4)10^{-6}	227
				$\pi\mu^+\mu^-$	(<2.4)10^{-6}	172
				$\pi\gamma\gamma$	(<1.1)10^{-4}	227

	$I^G(J^P)C$	Mass (MeV) / Mass² (GeV)²	Mean life (sec) / $c\tau$(cm)	Decays: Partial mode	Decays: Fraction[a]	p or p_{max} (MeV/c)[b]
K^0	$\frac{1}{2}(0^-)$	497.76	50% K_{Short}, 50% K_{Long}			
		±0.16				
K_S^0	$\frac{1}{2}(0^-)$	S=1.5*	0.862×10^{-10}	$\pi^+\pi^-$	(68.7 ±0.6)% S=1.6*	206
			±.006 S=1.2*	$\pi^0\pi^0$	(31.3)%	209
		$m^2=$ 0.248	$c\tau$ = 2.59	$\mu^+\mu^-$	(<3.1)10^{-7}	225
				e^+e^-	(<2.2)10^{-7}	249
				$\pi^+\pi^-\gamma$	c(3.3 ±1.2)10^{-3}	206
K_L^0	$\frac{1}{2}(0^-)$		5.38×10^{-8}	$\pi^0\pi^0\pi^0$	(21.5 ±0.7)% S=1.2*	139
			±0.19	$\pi^+\pi^-\pi^0$	(12.6 ±0.3)%	133
			$c\tau$ = 1614	$\pi\mu\nu$	(26.8 ±0.7)% S=1.2*	216
			S = 1.6*	$\pi e\nu$	(38.8 ±0.8)% S=1.2*	229
				$\pi^+\pi^-$	(0.157±.005)%	206
		$m_{K_S}-m_{K_L}=-0.469\times\frac{1}{\tau_S}$		$\pi^0\pi^0$	(0.121±.029)% S=1.5*	209
		± 0.015		$\pi^+\pi^-\gamma$	c(<0.4)10^{-3}	206
			$\frac{\Gamma(K_S\to\pi^+\pi^-\pi^0)}{\Gamma(K_L\to\pi^+\pi^-\pi^0)}<0.45$	$\gamma\gamma$	(5.2 ±0.5)10^{-4} S=1.6*	249
			(test of CP)	$e\mu$	(<0.6)10^{-5}	238
				$\mu^+\mu^-$	(<1.5)10^{-6}	225
				e^+e^-	(<1.7)10^{-5}	249
η	$0^+(0^-)^+$	548.8	Γ=(2.63±.64)keV	$\gamma\gamma$	(38.2 ±2.1)% } S=1.4*	274
		±0.6	Neutral decays	$\pi^0\gamma\gamma$	(2.0 ±2.8)% } S=1.4*	258
		$m^2=$ 0.301	71.5%	$3\pi^0$	e(31.4 ±2.7)% } S=1.4*	179
				$\pi^+\pi^-\pi^0$	(23.0 ±1.1)% S=1.2*	174
			Charged decays	$\pi^+\pi^-\gamma$	(5.4 ±0.5)%	236
			28.5%	$\pi^0e^+e^-$	(<0.01)%	258
				$\pi^+\pi^-e^+e^-$	(0.1 ±0.1)%	236
p	$\frac{1}{2}(\frac{1}{2}^+)$	938.256	stable			
		±0.005	$(>2\times10^{28}y)$			
		$m^2=$ 0.880				
n	$\frac{1}{2}(\frac{1}{2}^+)$	939.550	e$(0.932\pm0.014)10^3$	$pe^-\nu$	100 %	1
		±0.005	$c\tau=2.80\times10^{13}$			
		$m^2=$ 0.882				
		$m_p-m_n=-1.2933$				
		± 0.0001				

	$I^G(J^P)C$	Mass (MeV) Mass^2 (GeV)^2	Mean life (sec) $c\tau$(cm)	Decays: Partial mode	Decays: Fraction[a]	p or p_{max} (MeV/c)[b]
Λ	$0(\frac{1}{2}^+)$	1115.60	2.51×10^{-10}	$p\pi^-$	(65.3 ±1.3)%	100
		±0.08	±.03 S=1.3*	$n\pi^0$	(34.7)%	104
		S=1.3*	$c\tau$ = 7.54	$pe\nu$	(0.85±0.07)10^{-3} S=1.3*	163
		m^2= 1.245		$p\mu\nu$	(1.35±0.60)10^{-4}	131
Σ^+	$1(\frac{1}{2}^+)$	1189.40	0.802×10^{-10}	$p\pi^0$	(51.7 ±0.8)%	189
		±0.19	±.007	$n\pi^+$	(48.3)%	185
		S=1.7*	$c\tau$ = 2.41	$p\gamma$	(1.16±0.17)10^{-3} S=1.4*	225
		m^2 = 1.412		$n\pi^+\gamma$	(1.3 ±0.3)10^{-4}	185
		$m_{\Sigma^+}-m_{\Sigma^-}$ = -7.92		$\Lambda e^+\nu$	(2.02±0.47)10^{-5}	72
		±.13	$\frac{\Gamma(\Sigma^+\to\ell^+n\nu)}{\Gamma(\Sigma^-\to\ell^-n\nu)}$ = <.03 ←	$n\mu^+\nu$	(<1.1)10^{-5}	202
				$ne^+\nu$	(<0.7)10^{-5}	224
Σ^0	$1(\frac{1}{2}^+)$	1192.46	$<1.0\times10^{-14}$	$\Lambda\gamma$	100 %	75
		±0.12	$c\tau<3\times10^{-4}$	Λe^+e^-	d(5.45)10^{-3}	
		S=1.2*				
		m^2= 1.422				
Σ^-	$1(\frac{1}{2}^+)$	1197.32	e 1.49×10^{-10}	$n\pi^-$	100 %	193
		±0.11	±.03 S=2.1*	$ne^-\nu$	(1.06±0.05)10^{-3}	230
		S=1.3*	$c\tau$ = 4.47	$n\mu^-\nu$	(0.45±0.04)10^{-3}	210
		m^2 = 1.434		$\Lambda e^-\nu$	(0.60±0.06)10^{-4}	79
		$m_{\Sigma^0}-m_{\Sigma^-}$ = 4.86		$n\pi^-\gamma$	c(1.0 ±0.2)10^{-4}	193
		±.07				
Ξ^0	$\frac{1}{2}(\frac{1}{2}^+)$ f	1314.7	3.03×10^{-10}	$\Lambda\pi^0$	100 %	135
		±0.7	±.18	$p\pi^-$	(<0.9)10^{-3}	299
		m^2= 1.728	$c\tau$ = 9.10	$pe^-\nu$	(<1.3)10^{-3}	323
		$m_{\Xi^0}-m_{\Xi^-}$ = 6.6		$\Sigma^+e^-\nu$	(<1.5)10^{-3}	119
		±.7		$\Sigma^-e^+\nu$	(<1.5)10^{-3}	112
				$\Sigma^+\mu^-\nu$	(<1.5)10^{-3}	64
				$\Sigma^-\mu^+\nu$	(<1.5)10^{-3}	49
				$p\mu^-\nu$	(<1.3)10^{-3}	309
Ξ^-	$\frac{1}{2}(\frac{1}{2}^+)$ f	1321.25	1.66×10^{-10}	$\Lambda\pi^-$	100 %	139
		±0.18	±.04 S=1.1*	$\Lambda e^-\nu$	g(0.67±0.23)10^{-3}	190
		m^2= 1.746	$c\tau$ = 4.98	$\Sigma^0e^-\nu$	(<0.5)10^{-3}	122
				$\Lambda\mu^-\nu$	(<1.3)10^{-3}	163
				$\Sigma^0\mu^-\nu$	(<0.5)%	70
				$n\pi^-$	(<1.1)10^{-3}	303
				$ne^-\nu$	(<1.0)%	327
Ω^-	$0(\frac{3}{2}^+)$ f	1672.5±.5	$1.3^{+0.4}_{-0.3}\times10^{-10}$	$\Xi^0\pi^-$	Total of	293
		m^2= 2.797	$c\tau$ = 3.9	$\Xi^-\pi^0$	28 events	289
				ΛK^-	seen	210

*S = Scale factor = $\sqrt{\chi^2/(N-1)}$, where N ≈ number of experiments. S should be ≈ 1. If S > 1, we have enlarged the error of the mean, δx, i.e., δx→S δx. This convention is still inadequate, since if S >> 1, the experiments are probably inconsistent, and therefore the real uncertainty is probably even greater than Sδx. See text and ideogram in data card listings.

a. Quoted upper limits correspond to a 90% confidence level.

b. In decays with more than two bodies, P_{max} is the maximum momentum that any particle can have.

c. See data card listings for energy limits used in measuring this branching ratio.

d. Theoretical value; see also data card listings.

e. See note in data card listings.

f. Predicted from SU(3).

g. Assumes rate for $\Xi^-\to\Sigma^0 e^-\nu$ small compared with $\Xi^-\to\Lambda e^-\nu$.

Addendum to STABLE PARTICLES

	Magnetic moment	μ Decay parameters [a]
e	1.001 159 557 ±.000 000 030 $\frac{e\hbar}{2m_e c}$	
μ	1.001 166 14 ±.000 000 31 $\frac{e\hbar}{2m_\mu c}$	ρ = 0.752±0.003 η = - 0.12 ±0.21 ξ = 0.972±0.013 δ = 0.755±0.009 h = 1.00±0.13 $\lvert g_A/g_V\rvert = 0.86^{+0.33}_{-0.11}$ φ = 180° ±15°

	Mode	Partial rate (sec^{-1})		
$K^\pm$	$\mu\nu$	(51.54±0.30)10^6 S=1.3*	ΔI = ½ rule See Appendix I	
	$\pi\pi^0$	(16.95±0.25)10^6 S=1.2*		
	$\pi\pi^+\pi^-$	(4.51±0.03)10^6 S=1.1*		
	$\pi\pi^0\pi^0$	(1.38±0.04)10^6	Form factors See listings for λ, ξ	
	$\mu\pi^-\nu$	(2.58±0.09)10^6 S=2.0*		
	$e\pi^0\nu$	(3.93±0.06)10^6 S=1.2*		
K^0_S	$\pi^+\pi^-$	(0.797±.009)10^{10} S=1.4*	CP violation parameters	
	$\pi^0\pi^0$	(0.363±.007)10^{10} S=1.5*		
K^0_L	$\pi^0\pi^0\pi^0$	(3.99 ±0.20)10^6 S=1.3*	$\eta_{+-,00} = \frac{A(K_L\to\pi^+\pi^-,\pi^0\pi^0)}{A(K_S\to\pi^+\pi^-,\pi^0\pi^0)} = \lvert\eta_{+-,00}\rvert e^{i\phi_{+-,00}}$	ΔS = -ΔQ See listings
	$\pi^+\pi^-\pi^0$	(2.35 ±0.10)10^6 S=1.4*		
	$\pi\mu\nu$	(4.98 ±0.22)10^6 S=1.5*		
	$\pi e\nu$	(7.22 ±0.29)10^6 S=1.5*	$\lvert\eta_{+-}\rvert$=(1.92±0.05)10^{-3}, ϕ_{+-}=(44±5)° S=1.4*.	Form factors See listings for λ, ξ
	$\pi^+\pi^-$	(0.029±.001)10^6 S=1.2*	$\lvert\eta_{00}\rvert$=(2.5±0.8)10^{-3}, ϕ_{00} (23±32) S=1.5*	
	$\pi^0\pi^0$	(0.023±.006)10^6 S=1.5*		
η	Mode	Asymmetry parameter		
	$\pi^+\pi^-\pi^0$	(1.3±0.6)%		
	$\pi^+\pi^-\gamma$	(1.9±1.1)%		

	Magnetic Moment ($e\hbar/2m_pc$)		Decay parameters[b] Measured: α	Measured: φ(degree)	Derived: γ	Derived: Δ(degree)	g_A/g_V[b]	g_V/g_A[b]
p	2.792763 ±.000030							
n	-1.913148 ±.000066	$pe^-\nu$					-1.231±0.010 [δ=(176.1±6.4)°	
Λ	-0.73 ±.16 S=1/2*	$p\pi^-$	0.645±0.016	(-6.3±3.5)°	0.76	(7.5±3.9)°		
		$n\pi^0$	0.71 ±0.18					
		$pe\nu$					-0.83 ±0.18	
Σ^+		$p\pi^0$	-0.995±0.022					
		$n\pi^+$	+0.068±0.016	(167±20)°	-0.97	(-73^{+102}_{-10})°		
Σ^-		$n\pi^-$	-0.078±0.020 S=1.7*	(10±15)°	0.98	(246^{+14}_{-108})°		
		$ne^-\nu$					0.25 ±0.11	
		$\Lambda e^-\nu$						0.35±0.18
Ξ^0		$\Lambda\pi^0$	-0.35±0.08	(25±21)° S=1.3*	0.85	(229^{+14}_{-38})°		
Ξ^-		$\Lambda\pi^-$	-0.41±0.04	(-3±9)° S=1.3*	0.90	(172±18)°		

*S = scale factor. Quoted error includes scale factor; see footnote to main Stable Particles Table for definition.

a. $\lvert g_A/g_V\rvert$ defined by $g_A^2 = \lvert C_A\rvert^2+\lvert C'_A\rvert^2$, $g_V^2=\lvert C_V\rvert^2+\lvert C'_V\rvert^2$, and $\Sigma\langle \bar{e}\lvert\Gamma_i\rvert\mu\rangle\langle\bar{\nu}\lvert\Gamma_i(C_i+C'_i\gamma_5)\rvert\nu\rangle$;

φ defined by $\cos\phi = -R_e(C^*_AC'_V+C'_AC^*_V)/g_Ag_V$ [for more details, see text].

b. The definition of these quantities is as follows [for more details on sign convention, see text]:

$$\alpha = \frac{2\lvert s\rvert\lvert p\rvert\cos\Delta}{\lvert s\rvert^2+\lvert p\rvert^2};\qquad \beta = \sqrt{1-\alpha^2}\sin\phi;$$

$$\beta = \frac{-2\lvert s\rvert\lvert p\rvert\sin\Delta}{\lvert s\rvert^2+\lvert p\rvert^2}.\qquad \gamma = \sqrt{1-\alpha^2}\cos\phi.$$

g_A/g_V defined by $\langle B_f\lvert\gamma_\lambda(g_V-g_A\gamma_5)\rvert B_i\rangle$;

δ defined by $g_A/g_V = \lvert g_A/g_V\rvert e^{i\delta}$.

Quantities in italics have changed by more than one (old) standard deviation since January, 1969

Name	$I^G(J^P)C_n$ (⊢⊣ estab., ? = guess)	Mass M (MeV)	Width Γ (MeV)	M^2 ±ΓM[(a)] $(GeV)^2$	Partial decay modes: Mode	Partial decay modes: Fraction %	p or p_{max}[(b)] (MeV/c)
$\pi^{\pm}$(140)	$1^-(0^-)+$	139.58	0.0	0.019483	See Stable Particles Table		
π^0(135)		134.97	7.2 eV ±1.2 eV	0.018217			
η(549)	$0^+(0^-)+$	548.8 ±0.6	2.63 keV ±.64 keV	0.301 ±.000	All neutral	71 } See Stable Particles Table	
					$\pi^+\pi^-\pi^0 + \pi^+\pi^-\gamma$	29	
η_{0^+}(700) "ε" → ππ	$0^+(0^+)+$	≈700	≫100	≈0.5	$\pi\pi$	100	≈320
δ_{00} seems to stay near 90° from 650 to 900 MeV; see note in listings							
ρ(765)	$1^+(1^-)-$	765 ±10[(c)]	125 ±20[(c)]	0.585 ±.095	$\pi\pi$	≈100	356
					$\pi^{\pm}\pi^+\pi^-\pi^0$	< 0.2	243
					$\pi^+\pi^-\pi^+\pi^-$	< 0.15	243
					$\pi^{\pm}\gamma$	< 0.2	370
					$\eta\pi^{\pm}$	< 0.8	141
					e^+e^-	.0060±.0006 (d)	382
					$\mu^+\mu^-$	.0062±.0011 (e)	368
ω(784)	$0^-(1^-)-$	783.7 ±0.4 S = 1.8*	12.7 ±1.2	0.614 ±.010	$\pi^+\pi^-\pi^0$	87±4	328
					$\pi^+\pi^-$	> 0.3 (95% confidence)	366
					$\pi^0\gamma$	9.4±1.7	380
					e^+e^-	0.0066±.0017 S = 1.4*	392
					For upper limits, see footnote (f)		
η'(958) or X^0	$0^+(0^-)+$	957.7 ±0.8	< 4	0.917 <.004	$\eta\pi\pi$	*66 ± 4 S = 1.1**	231
$J^P = 2^-$ not excluded; see note in listings					$\rho^0\gamma$	*30 ± 3 S = 1.2**	173
See note (h), on name η'					$\gamma\gamma$ [note (g)]	4.7±2.9	479
					For upper limits see footnote (i)		
δ(962)	≥1 ( )	962 ±5	< 5	0.927 <.005	$\eta\pi$ possibly seen		305
These two could be related, see listings							
π_N(1016) → $K\bar{K}$	$1^-(0^+)+$	1016 ±10	≈25 } if res.	1.032 ±.025	$K^{\pm}K^0$	Only mode seen	111
					$\eta\pi$	< 80	342
Resonance, virtual bound state, or antibound state, still not distinguished							
φ(1019)	$0^-(1^-)-$	1019.5 ±0.6 S = 1.5*	3.9 ±0.4	1.039 ±.004	K^+K^-	*45.5 ± 3.3 S = 1.1**	126
					K_LK_S	*36.4 ± 3.4 S = 1.3**	110
					$\pi^+\pi^-\pi^0$ (incl. ρπ)	18.1±4.9 S = 1.5*	462
					e^+e^-	0.036±.003	510
					$\mu^+\mu^-$	$0.035^{+.035}_{-.018}$	499
					For upper limits see footnote (j)		
η_{0^+}(1060) "S*" → K_SK_S	$0^+(0^+)+$ if res.	1062 ±20§	≈80(?) see note (k)	1.13 ±.09	$\pi\pi$	< 65	513
					$K\bar{K}$	> 35	190
Resonance and scattering length both possible							
A1(1070)	$1^-(1^+)+$	1070§ ±20	95§ ±35	1.14 ±.10	3π see note (ℓ)	≈100	488
					$K\bar{K}$	< 0.25	201
Interpretation still slightly in doubt; $J^P = 2^-$ not excluded					[$G = (-1)^{\ell + I}$ forbids $K\bar{K}$]		

Name	$I^G(J^P)C_n$ (⊢⊣ estab., ? = guess)	Mass M (MeV)	Width Γ (MeV)	M^2 ±ΓM[(a)] $(GeV)^2$	Partial decay modes: Mode	Partial decay modes: Fraction %	p or p_{max}[(b)] (MeV/c)
B(1235)	$1^+(1^+)-$	1235 ±15§	*102 ±20§*	1.53 ±.13	$\omega\pi$	≈100	350
					$\pi\pi$	< 30 } Absence suggests J^P = Abn.	602
					$K\bar{K}$	< 2	371
					For other upper limits see footnote (m)		
f(1260)	$0^+(2^+)+$	1264 ±10§	151 ±25§	1.60 ±.19	$\pi\pi$	≈100	616
					$2\pi^+2\pi^-$	< 4	553
					$K\bar{K}$ indic. seen	≈ 3	389
D(1285)	$0^+(A)+$	1288 ±7 S = 2.3*	33 ±5 S = 1.1*	1.66 ±.04	$K\bar{K}\pi$ [mainly $\pi_N(1016)\pi$]	Seen	307
$J^P = 0^-, 1^+, 2^-$, with 1^+ favored					$\pi\pi\eta$	Possibly Large	485
					$\pi\pi\rho$	Not seen	354
$A2_L$(1280)	$1^-(2^+)+$	*1280 ±4 S = 1.7**	22 ±4	1.64 ±.028	ρπ (and π + neutrals)	Dominant } See note (n)	395
					$K\bar{K}$	Seen	405
					$\eta\pi$	Indication seen	511
$A2_H$(1320)	$1^-(2^+)+$	*1320 ±5 S = 2.1**	21 ±4	1.74 ±.028	ρπ (and π + neutrals)	Dominant } See note (n)	423
					$K\bar{K}$	Seen	436
					$\eta\pi$	Indication seen	535
E(1422)	$0^+(0^-)+$	1422 ±4	69 ±8	2.02 ±.10	$K^*\bar{K} + \bar{K}^*K$	50±10 } (so 100% $\bar{K}K\pi$)	153
$J^P = 1^+$ not excluded					$\pi_N(1016)\pi$	50±10	326
See note in listings					$\pi\pi\eta$	< 60	568
					$\pi\pi\rho$	Not seen	457
f'(1514)	$0^+(2^+)+$	1514 ±5	73 ±23 S = 1.8*	2.29 ±.11	$K\bar{K}$	72±12 } See note (o)	570
					$K^*\bar{K} + \bar{K}^*K$	10±10	294
					$\pi\pi$	< 14	744
					$\eta\pi\pi$	18±10	624
					$\eta\eta$	< 40	521
π/ρ(1540) "F_1" → $K^*\bar{K}$	1(A) ?	1540 ±5	40 ±15	2.37 ±.06	$K^*\bar{K} + \bar{K}^*K$	Only mode seen	321
Seen in only one experiment.							
π_A(1640) → 3π	$1^-(A)+$	1633 ±9 S = 1.2*	93 ±24	2.67 ±.15	3π	Dominant	788
$J^P = 2^-$ preferred					† [$\pi^{\pm}\rho^0$/all$\pi^{\pm}\pi^+\pi^-$	< 40	629
					† [$\pi^{\pm}f(\to\pi^+\pi^-)$/all$\pi^{\pm}\pi^+\pi^-$	$35\pm^{25}_{20}$]	304
					$\omega\pi\pi$	Possibly observed	592
					$\omega\rho$	Possibly observed	259
Low signal/background; may be partly Deck effect and (or) several resonances					$\pi\eta$	< 9	717
					$K\bar{K}$	Not seen	647
					$\pi^{\pm}2\pi^+2\pi^-$	< 10	710
– [R1(1630) is included in both the π_A(1640) and ρ_N(1660) listings]							

Name	$I^G(J^P)C_n$ ⊢⊣ estab. ? = guess	Mass M (MeV)	Width Γ (MeV)	M^2 ±Γ M[(a)] $(GeV)^2$	Partial decay modes: Mode	Fraction %	p or p_{max}[(b)] (MeV/c)
$\rho_N(1660)$	$1^+(N)-$	$1663^{(p)}$	111	2.77	2π	Dominant	820
"g" → 2π		±20§	±30§	±.18	$K\bar{K}$	8^{+8}_{-3}	666
	($J^P = 1^-, 3^-, \ldots$ with 3^- favored)				(Other modes under $\rho(1710)$)		
$\rho(1710)$? → 4π	$1^+(\ )-$	1714	110§	2.94	4π	Dominant	799
		±20§	±25	±.08	† [$\pi^\pm A_2^0(\to\pi^+\pi^-\pi^0)/\text{all}\,\pi^\pm\pi^+\pi^-\pi^0$	40 ± 20]	342
					† [$\pi^\pm \omega(\to\pi^+\pi^-\pi^0)/\text{all}\,\pi^\pm\pi^+\pi^-\pi^0$	25 ± 10]	669
	Not yet clear whether this is just an				† [$\rho^\pm\rho^0$	Seen]	386
	alternative mode of the $\rho_N(1660)$, or				$\pi^\pm\phi/\pi^\pm\pi^+\pi^-\pi^0$	< 11	542
	a different resonance; the branching				$\pi^\pm 2\pi^+ 2\pi^- \pi^0$	< 15	705
	ratios are therefore only tentative				2π (if $\neq \rho_N(1660)$)	< 10	846
→ See Note (q) for bumps grouped as R(1750), S(1930), ρ(2100), T(2200), ρ(2275), and $N\bar{N}$(2345).							
U(2375)	$1^+(\ )-$	2371	30	5.62	Seen in $\pi^- p \to pU^-$ and		
		±8	±20§	±.07	$p\bar{p} \to K_1^0 K_1^0 \omega$, $K_1 K_2 (n\pi^0)$		
→ See Note (q) for 5 bumps, $N\bar{N}$(2380), X^-(2500), X^-(2620), X^-(2800), X^-(2880),							
$K^+(494)$	$\underline{1/2}(0^-)$	493.82		0.244	See Stable Particles Table		
$K^0(498)$		497.76		0.248			
→							
$K^*(892)$	$\underline{1/2}(1^-)$	(±)*892.1* ±*0.4*	Charged K^* 50.1	0.796	$K\pi$	≈ 100	288
		($m_0 - m_\pm$ = 7 ±3)	±0.8	±.045	$K\pi\pi$	0.2	216
→→							
$K_A(1240)$ or C	$1/2(1^+)$	1243	90§	1.54	Q region. See note (r).		
		±6	±40	±.11			
→					$K\pi\pi$	Only mode seen.	478
K_A(1280 to 1360) ?	$\underline{1/2}(1^+)$	1280 to 1360 .			† [$K^*\pi$	Large]	276
	$J^P = 2^-$ not completely ruled out				† [$K\rho$	Seen]	0
$K_N(1420)$	$\underline{1/2}(2^+)$	(±)*1409*	*96*	1.985	$K\pi$	49.2 ± 3.4 } S=1.5*	609
		±*4* * S = *1.3*	±*7* S = *1.3* *	±.135	$K^*\pi$	*36.3 ± 3.1* }	406
	See note (s).				$K\rho$	8.0 ± 3.5 S=1.6*	311
					$K\omega$	4.2 ± 1.3 S=1.1*	291
	$J^P = 3^-$ still possible				$K\eta$	2.2 ± 1.6 S=1.4*	474
→							
$K_A(1775)$ or L	$\underline{1/2}$(A)	1775		3.15	$K\pi\pi$	Only mode seen	794
Interpretation in doubt; see note (t)	$J^P = 1^+, 2^-$ favored				† [$K^*(1420)\pi$	Large]	305
→							

→ The following bumps, excluded above, are listed among the data cards: σ(410); H(990); η_V(1080); A1.5(1170); $A2_2$(1320) ; ρρ(1410); K_SK_S(1440); φ(1650); R(1750); η or ρ(1830) → 4π; φ or π(1830) → ωππ; S(1930); ρ(2100); T(2200); ρ(2275); $N\bar{N}_{I=0}$(2380); X^-(2500); X^-(2620); X^-(2800); X^-(2880); κ(725); K_N(1080-1260); $K_{A(I=3/2)}$(1175); $K_{A(I=3/2)}$(1265); K_N(1660); $K^*(2240) \to \bar{Y}N$. (See note (q).)

* Quoted error includes scale factor $S = \sqrt{\chi^2/(N-1)}$. See footnote to Stable Particles Table.

† Square brackets indicate a subreaction of the previous (unbracketed) decay mode.

§ This is only an educated guess; the error given is larger than the error of the average of the published values (see listings for the latter).

(a) ΓM is approximately the half-width of the resonance when plotted against M^2.

(b) For decay modes into ≥ 3 particles, p_{max} is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated by using the averaged central mass values, without taking into account the widths of the resonances.

(c) The values given for M(ρ) and Γ(ρ) and their errors are not average values from various experiments, but rather are intended to give the range where we believe the actual values are most likely to fall. Contrast the results tabulated in this note (references in the listings):

	M(MeV)	Γ(MeV)	
ρ^0	774±5	111±5	From $e^+e^- \to \pi^+\pi^-$, fitted to Gounaris-Sakurai formula.
ρ^0	768±10	140±14	
ρ^0		105±15	From $\pi N \to \pi\pi N$, ππ phase shift analysis with Chew-Low extrapolation, and energy-independent width.
ρ^-	755±5	110± 9	
ρ^0	768±2	132±13	Similar to above, but energy-dependent width and off-shell corrections.
ρ^-	764±2	147±4	From $\pi N \to \pi\pi N$, fits in physical region, energy-dependent width.

Energy-independent width is a narrow-resonance approximation which tends to give lower mass and width.

(d) The quoted value of the rate $\rho^0 \to e^+e^-$ is the average from two $e^+e^- \to \pi^+\pi^-$ experiments (which alone also give an average of (0.0060±0.0006)%) and one photoproduction experiment of high mass resolution. Interference effects with ω decay are therefore believed to be small.

(e) Warning: The value for the rate $\rho^0 \to \mu^+\mu^-$ may be somewhat too high, due to possible interference with ω decay; the error is, however, chosen large enough to take account of this possibility (see notes in listings).

(f) Empirical limits on fractions for other decay modes of ω(784) are $\pi^+\pi^-\gamma < 5\%$, $\pi^0\pi^0\gamma < 1\%$, η+neutrals < 1.5%, $\mu^+\mu^- < 0.02\%$, $\pi^0\mu^+\mu^- < 0.2\%$.

(g) This $\eta' \to \gamma\gamma$ value is from a constrained fit under the assumption that ηππ, $\rho^0\gamma$, and γγ are the only existing decay modes. Note that direct measurement of the $\eta' \to \gamma\gamma$ branching fraction gave the slightly different result of $(5.5^{+3.6}_{-3.0})\%$.

(h) This 0^- meson was named η' on discovery, when it looked as if it completed the 0^- nonet. With the recent evidence that the E(1420) is probably also 0^-, it is no longer clear whether η' or E or both are mixed in with the π, η, K octet, so the name η' may be misleading.

(i) Empirical limits on fractions for other decay modes of η' (958): $\pi^+\pi^- < 2\%$, $\pi^+\pi^-\pi^0 < 5\%$, $\pi^+\pi^+\pi^-\pi^- < 1\%$, $\pi^+\pi^+\pi^-\pi^-\pi^0 < 1\%$, $6\pi < 1\%$, $\pi^+\pi^-e^+e^- < 0.6\%$, $\pi^0e^+e^- < 1.3\%$, $\eta e^+e^- < 1.1\%$, $\pi^0\rho^0 < 4\%$, $\pi^0\omega < 8\%$.

(j) Empirical limits on fractions for other decay modes of φ(1019) are $\pi^+\pi^- < 5\%$, $\eta\gamma < 8\%$, η+neutrals < 13%, $\pi^+\pi^-\gamma < 4\%$, $\omega\gamma < 5\%$, $\rho\gamma < 2\%$, $\pi^0\gamma < 0.35\%$.

(k) Width of $\eta_{0+}(1060) \to K_sK_s$: Average value from three bubble chamber experiments is Γ = 63±11 MeV, whereas two spark chamber experiments give Γ > 100 MeV. The latter also allow a scattering-length fit.

(ℓ) ρπ fraction of 3π mode difficult to distinguish because ρ bands cover most of the Dalitz plot.

(m) Empirical limits on fractions for decay modes of B(1235): ππ < 30%, $K\bar{K} < 2\%$, 4π < 50%, φπ < 1.5%, ηπ < 25%, $(KK)^\pm\pi^0 < 8\%$, $K_SK_S\pi^\pm < 2\%$, $K_SK_L\pi^\pm < 6\%$.

(n) Branching ratios can presently be given only for the overall A2 (splitting unresolved): $\rho\pi$ 85±4% (S=1.9*), $K\bar{K}$ 2.4±0.5%, $\eta\pi$ 12±4% (S=1.9*), $\eta'\pi$ 0.6±0.4%, $\pi^+\pi^-\pi^0$ ($\neq\rho\pi$) <20%.

(o) There is only a weak indication for a $K^*\bar{K} + \bar{K}^*K$ mode of the f' (1514). If this mode does not exist, the $K\bar{K}$ branching fraction will have to be reported as 80±13% (rather than 72±12% as given in the table), and $\eta\pi\pi$ as 20±13%.

(p) See B. French's compilation (Proc. 14th International Conf. High Energy Physics, Vienna, 1968, p. 91) for possible mass difference of charged and neutral $\rho_N(1660)$: M = 1640±20 MeV, Γ = 120±30 MeV for $\rho_N^{\pm}$, M = 1680±15 MeV, Γ = 200±50 MeV for ρ_N^0.

(q) We tabulate here Y = 0 bumps with M ≥ 1700 MeV, for which no satisfactory grouping into particles is yet possible. See listings.

Name	I^G	(J^P)	M(MeV)	Γ (MeV)	Decay modes observed	Tentative grouping
R2(1700)	1, 2		1700±15	≤30	$(MM)^- \to 1/3/>3$ charg. part. ≈ 43/56/1	ρ(1710)
$K\bar{K}$(1740)	1		1740	≈120	$K^0K^{\pm}$	R(1750)
R3(1750)	1, 2		1748±15	≤38	$(MM)^- \to 1/3/>3$ charg. part. > 14/< 80/15	
ρ(1900)	$1^+, 2^+$		1900±40	216±105	$\pi^+\pi^0$	S region
$N\bar{N}$(1925)	0, 1		1925	≈10	Structure in $\bar{p}p$ backward el. scattering	
S(1929)	1, 2		1929±14	≤35	$(MM)^- \to 3$ charged particles ≈ 92%	Seems to require>1 resonance
$N\bar{N}$(1945)	0, 1		1945	≈22	Structure in $\bar{p}p$ backward el. scattering	
ρππ(1985)	$1^+, 2^+, 3^+$		1985	≈100	$\rho^-\pi^+\pi^-$	
X^-(2086)	1, 2		2086±38	≈150	$(MM)^-$ backward	ρ(2100)
ρ(2120)	1^+	3^-(?)	2120	<249	$\pi^+\pi^-$, $\bar{p}p$	
$N\bar{N}$(2190)	1^-		2190	20–80	$\rho^0\rho^0\pi^0$, $\bar{p}p$	T region
	1		2190±10	≈85	Structure in $N\bar{N}$ total σ	
T(2195)	1, 2		2195±15	≤13	$(MM)^- \to 3$ charged particles ≈ 94%	Seems to require>1 resonance
3π(2207)	$\leq 3^-$		2207±13	62±52	$\pi^+\pi^-\pi^0$	
4π(2200)	$1^+, 2^+, 3^+$		2200	≈130	$\rho^-\pi^+\pi^-$	
KKω(2176)	$0^-, 1^+$		2176± 5	20^{+16}_{-2}	$K_1^0K_1^0\omega$	
X^-(2260)	1, 2		2260±18	≤25	$(MM)^-$ backward	ρ(2275)
ρ(2290)	1^+	5^-(?)	2290	<165	$\pi^+\pi^-$, $\bar{p}p$	
$N\bar{N}$(2380)	0		2380±10	≈140	Structure in $N\bar{N}$ total σ	
$N\bar{N}$(2345)	1		2345±10	≈140	Structure in $N\bar{N}$ total σ	
U(2375)	1^-	Included on the main Meson Table, and summarized in listings				
X^-(2500)	1, 2		2500±32	≈87	$(MM)^-$ backward	
X^-(2620)	1, 2		2620±20	85±30	$(MM)^-$	
X^-(2800)	1, 2		2800±20	46±10	$(MM)^-$	
X^-(2880)	1, 2		2880±20	≤15	$(MM)^-$	

(r) See note in listings. Some investigators see a broad enhancement in mass (Kππ) from 1200–1350 MeV (the Q region), and others see structure. Only the $K_A^*(1240)$ or C seems well established, whereas the structures from 1280 to 1360 MeV cannot be disentangled. For the whole Q region the decay rate into $K^*(892)\pi$ is large, and a Kρ decay is seen. The Kη, Kω, and Kπ rates are less than a few percent.

(s) The average mass of the neutral K_N^* is 1423±4, or 14 MeV higher than that of the charged K_N^*. But these differences are very unreliable; see typed note under $K^*(892)$ mass.

(t) No width and branching ratios can be quoted since presence of kinematic $K_N(1420)\pi$ enhancement makes background subtraction difficult.

Mixing Angles from Quadratic SU(3) Mass Formula:

$J^P = 0^-$ Possible Nonet [π, K, η; η'] θ = 10.4±0.2°
$= 0^-$ Alternative Nonet [π, K, η; E] θ = 6.2±0.1°
$= 1^-$ [ρ(765±15), K^*, φ; ω] θ = 39.9±1.1°
$= 2^+$ [A_{2H}, K_N(1420), f'; f] θ = 29.9±2.2°

Of the two iso-singlets, the "mainly-octet" one is written first, followed by a semicolon.

GENERAL ATOMIC AND NUCLEAR CONSTANTS*

N	$= 6.022169(40)\times10^{23}$ mole^{-1} (based on $A_{C^{12}} = 12$)
c	$= 2.997925(10)\times10^{10}$ cm sec^{-1}
e	$= 4.803250(21)\times10^{-10}$ esu $= 1.6021917(70)\times10^{-19}$ coulomb
1 MeV	$= 1.6021917(70)\times10^{-6}$ erg
ħ	$= 6.582183(22)\times10^{-22}$ MeV sec
	$= 1.0545919(80)\times10^{-27}$ erg sec
ħc	$= 1.9732891(66)\times10^{-11}$ MeV cm = 197.32891(66) MeV fermi
α	$= e^2/\hbar c = 1/137.03602(21)$
$k_{Boltzmann}$	$= 1.380622(59)\times10^{-16}$ erg K^{-1}
	$= 8.61708(37)\times10^{-11}$ MeV K^{-1} = 1 eV/11604.85(49)K
m_e	$= 0.5110041(16)$ MeV $= 9.109558(54)\times10^{-31}$ kg
m_p	= 938.2592(52) MeV = 1836.109(11) m_e = 6.72211(63) $m_{\pi^{\pm}}$
	= 1.00727661(8) m_1 (where m_1 = 1 amu = $\frac{1}{12}m_{C^{12}}$ = 931.4812(52) MeV)
r_e	$= e^2/m_ec^2 = 2.817939(13)$ fermi (1 fermi = 10^{-13} cm)
$\lambda\!\!\!^{-}_e$	$= \hbar/m_ec = r_e\alpha^{-1} = 3.861592(12)\times10^{-11}$ cm
$a_{\infty\,Bohr}$	$= \hbar^2/m_ee^2 = r_e\alpha^{-2} = 0.52917715(81)$ A (1A = 10^{-8} cm)
$\sigma_{Thomson}$	$= \frac{8}{3}\pi r_e^2 = 0.6652453(61)\times10^{-24}$ cm^2 = 0.6652453(61) barns
μ_{Bohr}	$= e\hbar/2m_ec = 0.5788381(18)\times10^{-14}$ MeV gauss^{-1}
$\mu_{nucleon}$	$= e\hbar/2m_pc = 3.152526(21)\times10^{-18}$ MeV gauss^{-1}
$\frac{1}{2}\omega^e_{cyclotron}$	$= e/2m_ec = 8.794014(27)\times10^{6}$ rad sec^{-1} gauss^{-1}
$\frac{1}{2}\omega^p_{cyclotron}$	$= e/2m_pc = 4.789484(27)\times10^{3}$ rad sec^{-1} gauss^{-1}

Hydrogen-like atom (nonrelativistic, μ = reduced mass):

$$\frac{v}{c}\Big)_{rms} = \frac{ze^2}{n\hbar c};\ E_n = \frac{\mu}{2}v^2 = \frac{\mu z^2e^4}{2(n\hbar)^2};\ a_n = \frac{n^2\hbar^2}{\mu ze^2}$$

$R_\infty = m_ee^4/2\hbar^2 = m_ec^2\alpha^2/2 = 13.605826(45)$ eV (Rydberg)

pc = 0.3 Hρ(MeV, kilogauss, cm); 0.3 (which is 10^{-11}c) enters because there are ≈ 300 "volts"/esu volt.

1 year (sidereal)	= 365.256 days = 3.1557×10^7 sec (≈ $\pi\times10^7$ sec)
density of dry air	= 1.205 mg cm^{-3} (at 20°C, 760 mm)
acceleration by gravity	= 980.62 cm sec^{-2} (sea level, 45°)
gravitational constant	$= 6.6732(31)\times10^{-8}$ cm^3 g^{-1} sec^{-2}
1 calorie (thermochemical)	= 4.184 joules
1 atmosphere	= 1033.2275 g cm^{-2}
1 eV per particle	= 11604.85(49)°K (from E = kT)

NUMERICAL CONSTANTS

π	= 3.1415927	1 rad	= 57.2957795 deg
e	= 2.7182818	1/e	= 0.3678794
ln 2	= 0.6931472	ln 10	= 2.3025851
$\log_{10}2$	= 0.3010300	$\log_{10}e$	= 0.4342945

*Compiled by Stanley J. Brodsky, based mainly on the adjustment of the fundamental physical constants by B. N. Taylor, W. H. Parker, and D. N. Langenberg, Rev. Mod. Phys. 41, 375 (1969). The figures in parentheses correspond to the 1 standard deviation uncertainty in the last digits of the main number.

BARYONS January 1970

[See notes on N's and Δ's, on possible Z^*'s, and on Y^*'s at the beginning of those sections in the data listings; also see notes on individual resonances in the listings.]

Particle or resonance[a]	I (J^P)	π or K Beam T(GeV) p(GeV/c) $\sigma = 4\pi\lambda\!\!\!^-{}^2$ (mb)	Mass[b] (MeV)	Γ[b] (MeV)	$M^2 \pm \Gamma M$[c] (GeV^2)	Decay Modes: Partial Mode	Decay Modes: Fraction %	p or p_{max} (MeV/c)
N								
p n	$1/2(1/2^+)$		938.3 939.6		0.880 0.883	See Stable Particles		
N'(1470)	$1/2(1/2^+)\ P'_{11}$	T=0.53πp p=0.66 σ=27.8	1435 to 1505	200 to 400	2.16 ±0.36	Nπ Nππ	60 40	420 368
N'(1520)	$1/2(3/2^-)\ D'_{13}$	T=0.61 p=0.74 σ=23.5	1510 to 1540	105 to 150	2.31 ±0.18	Nπ Nππ Nη	50 50 ~0.5	456 410 150
N'(1535)	$1/2(1/2^-)\ S'_{11}$	T=0.64 p=0.76 σ=22.5	1500 to 1600	50 to 160	2.36 ±0.18	Nπ Nη Nππ	34 66 small	467 182 422
N(1670)	$1/2(5/2^-)\ D_{15}$	T=0.87 p=1.00 σ=15.6	1655 to 1680	105 to 175	2.79 ±0.24	Nπ Nππ ΛK Nη	42 58 < .1 < .3	560 525 200 368
N(1688)	$1/2(5/2^+)\ F_{15}$	T=0.90 p=1.03 σ=14.9	1680 to 1692	105 to 180	2.85 ±0.21	Nπ Nππ ΛK Nη	60 40 < .1 < .2	572 538 231 388
N''(1700)	$1/2(1/2^-)\ S''_{11}$	T=0.92 p=1.05 σ=14.3	1665 to 1765	100 to 400	2.89 ±0.44	Nπ ΛK Nη	70 5 ~ 3	580 250 340
N''(1780)	$1/2(1/2^+)\ P''_{11}$	T=1.07 p=1.20 σ=12.2	1750 to 1860	270 to 450	3.17 ±0.62	Nπ ΛK Nη	34 ~ 1 ~10	633 353 476
N(1860)	$1/2(3/2^+)\ P_{13}$	T=1.22 p=1.36 σ=10.4	1840 to 1900	310 to 450	3.46 ±0.62	Nπ Nππ ΛK Nη	27 <16 ~ 4	685 657 437 545
N(1990)	$1/2(7/2^+)\ F_{17}$	T=1.49 p=1.63 σ=8.34	1980 to 2000	220 to 250	3.96 ±0.47	Nπ Nππ	11	766 743
N'''(2040)	$1/2(3/2^-)\ D'''_{13}$	T=1.60 p=1.73 σ=7.70	2030 to 2060	240 to 290	4.16 ±0.56	Nπ Nππ	17	797 775
N(2190)	$1/2(7/2^-)\ G_{17}$	T=1.94 p=2.07 σ=6.21	2000 to 2260	300	4.80 ±0.65	Nπ Nππ	35	888 868
N(2650)	$1/2(\ ?^-)$	T=3.12 p=3.26 σ=3.67	2650	360	7.02 ±0.95	Nπ Nππ	(J+1/2)x =0.45[f]	1154 1140
N(3030)	$1/2(\ ?\ )$	T=4.27 p=4.41 σ=2.62	3030	400	9.18 ±1.21	Nπ Nππ	(J+1/2)x =0.05[f]	1366 1354
Δ								
Δ(1236)	$3/2(3/2^+)\ P'_{33}$	T=0.195 (++) p=0.304 σ=91.8	1236.0 ±0.6 $m_0 - m_{++} = .45 \pm .85$ $m_- - m_{++} = 7.9 \pm 6.8$	120 ±2	1.53 ±0.15	Nπ $N\pi^+\pi^-$ Nγ	99.4 0 ~0.6	231 89 262
Δ(1650)	$3/2(1/2^-)\ S_{31}$	T=0.83 p=0.96 σ=16.4	1620 to 1695	130 to 250	2.72 ±0.25	Nπ Nππ	27 73	547 511
Δ(1670)	$3/2(3/2^-)\ D_{33}$	T=0.87 p=1.00 σ=15.6	1650 to 1690	175 to 300	2.79 ±0.40	Nπ Nππ	13	560 525
Δ(1890)	$3/2(5/2^+)\ F_{35}$	T=1.28 p=1.42 σ=9.88	1840 to 1910	135 to 380	3.57 ±0.52	Nπ Nππ	17	704 677
Δ(1910)	$3/2(1/2^+)\ P_{31}$	T=1.33 p=1.46 σ=9.54	1835 to 1935	230 to 420	3.65 ±0.62	Nπ Nππ	25	716 691
Δ(1950)	$3/2(7/2^+)\ F_{37}$	T=1.41 p=1.54 σ=8.90	1935 to 1980	140 to 220	3.80 ±0.39	Nπ Δ(1236)π ΣK Σ(1385)K Δ(1236)ρ	45 ≈50 2.4 1.4 seen	741 571 460 232
Δ(2420)	$3/2(11/2^+)$	T=2.50 p=2.64 σ=4.68	2420	310	5.86 ±0.75	Nπ Nππ	11 >20	1023 1006
Δ(2850)	$3/2(\ ?^+\ )$	T=3.71 p=3.85 σ=3.05	2850	400	8.12 ±1.14	Nπ Nππ	(J+1/2)x =0.25[f]	1266 1254
Δ(3230)	$3/2(\ ?\ )$	T=4.94 p=5.08 σ=2.25	3230	440	10.4 ±1.4	Nπ Nππ	(J+1/2)x =0.05[f]	1475 1464
Λ								
Λ	$0(1/2^+)$		1115.6		1.24	See Stable Particles		
Λ(1405)	$0(1/2^-)\ S_{01}$	$p < 0\ K^-p$	1405 ±5[g]	40 ±10[g]	1.97 ±0.06	Σπ	100	142
Λ'(1520)	$0(3/2^-)\ D'_{03}$	p=0.389 σ=84.5	1518 ±2[g]	16 ±2[g]	2.30 ±0.02	NK̄ Σπ Λππ Λγ Σππ	46±1 41±1 9.6±.6 .8±.2 1.0±.2	237 260 252 351 144
Λ'(1670)	$0(1/2^-)\ S'_{01}$	p=0.74 σ=28.5	1670	30	2.79 ±0.05	NK̄ Λη Σπ	15 35 50	410 66 393
Λ''(1690)	$0(3/2^-)\ D''_{03}$	p=0.78 σ=26.1	1690	27 to 85	2.86 ±0.07	NK̄ Σπ Λππ Σππ	20 55 ≈ 15 ≈ 10	429 409 415 352
Λ(1815)	$0(5/2^+)\ F_{05}$	p=1.05 σ=16.7	1815 ±5[g]	75 ±10[g]	3.30 ±0.13	NK̄ Σπ Σ(1385)π	65±1 11±1 17±3	537 504 358
Λ(1830)	$0(5/2^-)\ D_{05}$	p=1.09 σ=15.8	1835	66 to 145	3.37 ±0.18	NK̄ Σπ	10 30	550 515
Λ(2100)	$0(7/2^-)\ G_{07}$	p=1.68 σ=8.68	2100	40 to 145	4.41 ±0.21	NK̄ Σπ Λη ΞK Λω	25 ~ 1 < 3 ~.5 < 10	748 699 617 483 443
Λ(2350)	$0(\ ?\ )$	p=2.29 σ=5.85	2350	150	5.52 ±0.35	NK̄	(J+1/2)x =0.6[f]	913

	Particle or resonance[a]	I (J^P)	π or K Beam T(GeV) p(GeV/c) $\sigma = 4\pi\lambda\!\!\!^{-2}$ (mb)	Mass[b] (MeV)	Γ^b (MeV)	$M^2 \pm \Gamma M^c$ (GeV^2)	Decay Modes: Partial Mode	Decay Modes: Fraction %	p or p_{max}[d] (MeV/c)
	Σ	$1(1/2^+)$		(+)1189.4 (0)1192.5 (-)1197.3		1.41 1.42 1.43	See Stable Particles		
→→→→	Σ(1385)	$1(3/2^+)\ P_{13}$	$p < 0\ K^-p$	(+)1383±1 S=1.3* (-)1386±2 S=2.2*	(+)36±3 S=1.9* (-)36±6 S=3.5*!	1.92 ±0.05	Λπ Σπ	90±3 10±3 S=1.4*	208 117
→	Σ(1670)	$1(3/2^-)\ D_{13}$	p=0.74 σ=28.5	1670	50	2.79 ±0.08	$N\bar{K}$ Σπ Λπ Σππ [Λ(1405)π][e] Λππ	8 50 32 <14 [< 6] <11	410 387 447 326 207 397
		The branching ratios as reported here are from formation experiments. Production experiments still confused. See note in listings.							
	Σ(1750)	$1(1/2^-)\ S_{11}$	p=0.91 σ=20.7	1750	80	3.06 ±0.14	$N\bar{K}$ Λπ Ση	~15 ~20 seen	483 507 55
→	Σ(1765)	$1(5/2^-)\ D_{15}$	p=0.94 σ=19.6	1765 ±5[g]	60 to 146	3.12 ±0.21	$N\bar{K}$ Λπ Λ(1520)π Σ(1385)π Σπ	45±1 15±2 15±2 13±2 ~ 1	496 518 187 315 461
	Σ(1915)	$1(5/2^+)\ F_{15}$	p=1.25 σ=13.0	1910	50	3.65 ±0.10	$N\bar{K}$ Λπ Σπ	10 5 .4	616 622 571
		Formation and production experiments do not agree.[h]							
→	Σ(2030)	$1(7/2^+)\ F_{17}$	p=1.52 σ=9.93	2030	80 to 170	4.12 ±0.24	$N\bar{K}$ Λπ Σπ ΞK	10 35 5 < 2	700 700 652 412
	Σ(2250)	1(?)	p=2.04 σ=6.76	2250	200	5.06 ±0.45	$N\bar{K}$	(J+1/2)x =0.4[f]	849
	Σ(2455)	1(?)	p=2.57 σ=5.09	2455	100	6.03 ±0.25	$N\bar{K}$	(J+1/2)x =0.3[f]	979
→	Σ(2595)	1(?)	p=2.95 σ=4.30	2595	~140	6.73 ±0.36	$N\bar{K}$	(J+1/2)x =0.25[f]	1064
	Ξ	$1/2(1/2^+)$		(0)1314.7 (-)1321.3		1.73 1.75	See Stable Particles		
→→	Ξ(1530)	$1/2(3/2^+)$ p-wave		(0)1528.9±1.1 (-)1533.8±1.9	7.3 ±1.7	2.34 ±0.01	Ξπ	100	144
	Ξ(1820)	1/2(?)		1820	≈30	3.31 ±0.05	$\Lambda\bar{K}$ Ξπ Ξ(1530)π $\Sigma\bar{K}$	30 10 30 30	396 413 234 306
	Ξ(1930)	1/2(?)		1930	110	3.72 ±0.21	Ξπ $\Lambda\bar{K}$	large small	499 502
	Ξ(2030)	1/2(?)		2030	50	4.12 ±0.11	Ξπ $\Lambda\bar{K}$ $\Sigma\bar{K}$ Ξ(1530)π	small ~20 ~70 small	573 587 524 421
	Ξ(2250)	1/2(?)		2250	130	5.06 0.29	$\Lambda\bar{K}\pi$ $\Sigma\bar{K}\pi$ Ξππ	seen seen seen	689 631 701
	Ξ(2500)	1/2(?)		2500	60	6.25 0.15	Ξππ $\Lambda\bar{K}\pi$	seen seen	839 839
	Ω^-	$0(3/2^+)$		1672.4		2.80	See Stable Particles		

* Quoted error includes an S(scale) factor. See footnote to Stable Particles Table.

→ An arrow at the left of the Table indicates a candidate that has been omitted because the evidence for the existence of the effect and (or) for its interpretation as a resonance is open to considerable question. See listings for information on the following: N(1700) D_{13}, N(3245), N(3690), N(3755), Δ(1690) P_{33}, Δ(1960) D_{35}, Δ(2160) P_{33}, Z_0(1865), Z_1(1900), Λ(1330), Λ(1680) P_{01}, Λ(1800) P_{01}, Λ(1860) F_{07}, Λ(2015) F_{07}, Σ(1440), Σ(1480), Σ(1560) P_{11}, Σ(1620), Σ(1690), Σ(1880) P_{11}, Σ(2130) G_{17}, Σ(3000), Ξ(1630), Ξ(1700).

a. For the baryon states, the name [such as N'(1470)] contains the mass, which shifts by 5 or 10 MeV with each new analysis. The value chosen is the rounded average from Table II of the note on N's and Δ's in the baryon listings. The convention for using primes in the names is as follows: when there is more than one resonance on a given Argand diagram, the first has been designated with a prime, the second with a double prime, etc. The name (col. 1) is the same as can be found in large print in the listings.

b. See note on N's and Δ's in baryon listings. For M and Γ we report here an interval instead of an average. Averages are appropriate if each result is based on independent measurements, but inappropriate here where the spread in parameters arises because different models or procedures have been applied to a common set of data.

c. For this column M is the rounded average which also appears in the name column and Γ is the average quoted on Table II of the N's and Δ's note in the baryon listings.

d. For decay modes into ≥3 particles p_{max} is the maximum momentum that any of the particles in the final state can have. The momenta have been calculated using the averaged central mass values, without taking into account the widths of the resonances.

e. Square brackets indicate a sub-reaction of the previous unbracketed decay mode.

f. This state has been seen only in total cross sections. J is not known; x is Γ_{el}/Γ.

g. This is only an educated guess; the error given is larger than the error of the average of the published values (see listings for the latter).

h. Branching ratios quoted here are from formation experiments which require a small D_{15} resonant amplitude in this region. Production experiments report a state at this mass of unknown J^P, decaying mainly into Σπ.

Caption for SU(3) Isoscalar Coefficient Tables (next page)

Starting Jan. 1970 we have relabeled the 8×8 table (and changed the 8×10 table) to conform with the convention that the first particle shall be a baryon, the second a meson. This convention is advocated by R. Levi Setti in his report to the 1969 Lund Conference, and our coefficients now agree with Levi Setti's Table II.

The changes that have been made, and their motivation, are as follows: The deSwart table of 8×8 is merely labeled with symbols like ($I_1 = 1/2$, $Y_1 = 1$, $I_2 = 1$, $Y_2 = 0$), which can be read either as (Nπ) or (KΣ). Since there are no decuplet mesons, his 8×10 table is unambiguous; it must be read with the meson first. Accordingly, before 1970 we labeled the meson first on both tables.

We now realize that this old convention violates the other convention that the N, Nπ coupling shall be D + F (as opposed to -D + F). To get D + F we must use the first line of the "N" table, which reads $\cdots\ 3\ \sqrt{5}/10\,|8_D\rangle + 1/2\,|8_F\rangle$ as opposed to $\cdots\ -3\sqrt{5}/10\,|8_D\rangle + 1/2\,|8_F\rangle$. The first line must then be labeled Nπ rather than KΣ, i.e., with the baryon first.

Levi Setti further advocates the convention of writing the baryon first for SU(2) as well as SU(3). For example, the sign of the amplitudes as plotted on his and our Argand plots comes from using our SU(2) Clebsch-Gordan coefficients (Condon Shortley notation) and writing the baryon first. To make it easier to abide by this universal convention we have changed deSwart's 8×10 SU(3) table to 10×8, with the help of his Eq. (14.3):

$$\langle \mu_2 \mu_1 | \mu \rangle = \xi_1 (-1)^{I_1+I_2-I} \langle \mu_1 \mu_2 | \mu \rangle .$$

CLEBSCH-GORDAN COEFFICIENTS AND SPHERICAL HARMONICS

Note: A $\sqrt{\ }$ is to be understood over every coefficient; e.g., for -8/15 read $-\sqrt{8/15}$.

Notation:

	J	J	...
	M	M	...
m_1 m_2			
m_1 m_2	Coefficients		
. .			

$$Y_1^0 = \sqrt{\frac{3}{4\pi}}\cos\theta$$

$$Y_1^1 = -\sqrt{\frac{3}{8\pi}}\sin\theta\, e^{i\phi}$$

$$Y_2^0 = \sqrt{\frac{5}{4\pi}}\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$$

$$Y_2^1 = -\sqrt{\frac{15}{8\pi}}\sin\theta\cos\theta\, e^{i\phi}$$

$$Y_2^2 = \frac{1}{4}\sqrt{\frac{15}{2\pi}}\sin^2\theta\, e^{2i\phi}$$

$$Y_\ell^{-m} = (-1)^m Y_\ell^{m*}$$

$$\langle j_1 j_2 m_1 m_2 | j_1 j_2 J M\rangle = (-1)^{J-j_1-j_2}\langle j_2 j_1 m_2 m_1 | j_2 j_1 J M\rangle$$

1/2 × 1/2

M	m_1	m_2	J = 1	J = 0
+1	+1/2	+1/2	1	
0	+1/2	-1/2	1/2	1/2
0	-1/2	+1/2	1/2	-1/2
-1	-1/2	-1/2	1	

1 × 1/2

M	m_1	m_2	J = 3/2	J = 1/2
+3/2	+1	+1/2	1	
+1/2	+1	-1/2	1/3	2/3
+1/2	0	+1/2	2/3	-1/3
-1/2	0	-1/2	2/3	1/3
-1/2	-1	+1/2	1/3	-2/3
-3/2	-1	-1/2	1	

2 × 1/2

M	m_1	m_2	J = 5/2	J = 3/2
+5/2	+2	1/2	1	
+3/2	+2	-1/2	1/5	4/5
+3/2	+1	+1/2	4/5	-1/5
+1/2	+1	-1/2	2/5	3/5
+1/2	0	+1/2	3/5	-2/5
-1/2	0	-1/2	3/5	2/5
-1/2	-1	+1/2	2/5	-3/5
-3/2	-1	-1/2	4/5	1/5
-3/2	-2	+1/2	1/5	-4/5
-5/2	-2	-1/2	1	

3/2 × 1/2

M	m_1	m_2	J = 2	J = 1
+2	+3/2	+1/2	1	
+1	+3/2	-1/2	1/4	3/4
+1	+1/2	+1/2	3/4	-1/4
0	+1/2	-1/2	1/2	1/2
0	-1/2	+1/2	1/2	-1/2
-1	-1/2	-1/2	3/4	1/4
-1	-3/2	+1/2	1/4	-3/4
-2	-3/2	-1/2	1	

2 × 1

M	m_1	m_2	J = 3	J = 2	J = 1
+3	+2	+1	1		
+2	+2	0	1/3	2/3	
+2	+1	+1	2/3	-1/3	
+1	+2	-1	1/15	1/3	3/5
+1	+1	0	8/15	1/6	-3/10
+1	0	+1	6/15	-1/2	1/10
0	+1	-1	1/5	1/2	3/10
0	0	0	3/5	0	-2/5
0	-1	+1	1/5	-1/2	3/10
-1	0	-1	6/15	1/2	1/10
-1	-1	0	8/15	-1/6	-3/10
-1	-2	+1	1/15	-1/3	3/5
-2	-1	-1	2/3	1/3	
-2	-2	0	1/3	-2/3	
-3	-2	-1	1		

3/2 × 1

M	m_1	m_2	J = 5/2	J = 3/2	J = 1/2
+5/2	+3/2	+1	1		
+3/2	+3/2	0	2/5	3/5	
+3/2	+1/2	+1	3/5	-2/5	
+1/2	+3/2	-1	1/10	2/5	1/2
+1/2	+1/2	0	3/5	1/15	-1/3
+1/2	-1/2	+1	3/10	-8/15	1/6
-1/2	+1/2	-1	3/10	8/15	1/6
-1/2	-1/2	0	3/5	-1/15	-1/3
-1/2	-3/2	+1	1/10	-2/5	1/2
-3/2	-1/2	-1	3/5	2/5	
-3/2	-3/2	0	2/5	-3/5	
-5/2	-3/2	-1	1		

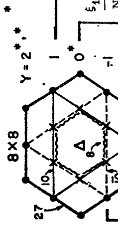
1 × 1

M	m_1	m_2	J = 2	J = 1	J = 0
+2	+1	+1	1		
+1	+1	0	1/2	1/2	
+1	0	+1	1/2	-1/2	
0	+1	-1	1/6	1/2	1/3
0	0	0	2/3	0	-1/3
0	-1	+1	1/6	-1/2	1/3
-1	0	-1	1/2	1/2	
-1	-1	0	1/2	-1/2	
-2	-1	-1	1		

Changed to Baryon-First convention, Jan 1970. See caption on previous page.

SU(3) ISOSCALAR FACTORS, adapted from J.J. de Swart, Rev. Mod. Phys. 35, 916 (1963).

{8} ⊗ {8} = {27} ⊕ {10} ⊕ {10*} ⊕ {8}₁ ⊕ {8}₂ ⊕ {1}.



Multiplicity of 27; ● = 1, × = 2, Δ = 3

* Five single-coefficient tables are omitted. The one involving a {10*} has a negative coefficient, i.e. (NK|10*) = -1. The others, involving {27} and {10}, are all +1.

Y = 1 I = 1/2 N

ξ_1 →	27 +	8D +	8F −	10* −
Nπ	$\sqrt{5}/10$	$3\sqrt{5}/10$	1/2	-1/2
ΣK	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	1/2	-1/2
Nη	$3\sqrt{5}/10$	$-\sqrt{5}/10$	1/2	-1/2
ΛK	$3\sqrt{5}/10$	$-\sqrt{5}/10$	-1/2	-1/2

Y = 1 I = 3/2 Δ

ξ_1 →	27 +	10 −
Nπ	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK	$\sqrt{2}/2$	$\sqrt{2}/2$

Y = 0 I = 0 Λ

ξ_1 →	27 +	8D +	1 +	8F −
NK̄	$\sqrt{15}/10$	$\sqrt{10}/10$	1/2	$\sqrt{2}/2$
ΞK	$-\sqrt{15}/10$	$-\sqrt{10}/10$	-1/2	$\sqrt{2}/2$
Σπ	$-\sqrt{10}/20$	$-\sqrt{15}/5$	$\sqrt{6}/4$	0
Λη	$3\sqrt{30}/20$	$-\sqrt{5}/5$	$-\sqrt{2}/4$	0

Y = 0 I = 1 Σ

ξ_1 →	27 +	8D +	8F −	10 −	10* −
NK̄	$\sqrt{5}/5$	$-\sqrt{30}/10$	$\sqrt{6}/6$	$-\sqrt{6}/6$	$\sqrt{6}/6$
ΞK	$\sqrt{5}/5$	$-\sqrt{30}/10$	$-\sqrt{6}/6$	$\sqrt{6}/6$	$-\sqrt{6}/6$
Σπ	0	0	$\sqrt{6}/3$	$\sqrt{6}/6$	$-\sqrt{6}/6$
Ση	$\sqrt{30}/10$	$\sqrt{5}/5$	0	1/2	1/2
Λπ	$\sqrt{30}/10$	$\sqrt{5}/5$	0	-1/2	-1/2

Y = -1 I = 1/2 Ξ

ξ_1 →	27 +	8D +	8F −	10 −
Ξπ	$-\sqrt{5}/10$	$-3\sqrt{5}/10$	1/2	1/2
ΣK̄	$\sqrt{5}/10$	$3\sqrt{5}/10$	1/2	1/2
Ξη	$3\sqrt{5}/10$	$-\sqrt{5}/10$	-1/2	1/2
ΛK̄	$3\sqrt{5}/10$	$-\sqrt{5}/10$	1/2	-1/2

Y = -1 I = 3/2

ξ_1 →	27 +	10* −
Ξπ	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK̄	$\sqrt{2}/2$	$\sqrt{2}/2$

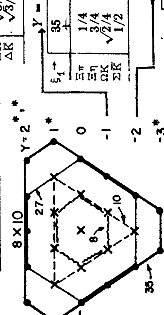
The Phase Factor $\xi_1 = \pm 1$, from de Swart's Table I, enters in his symmetry formula (14.3):

$$\langle \mu_1 \mu_2 | \mu \rangle = \xi_1 (-1)^{I_1+I_2-I} \langle \mu_2 \mu_1 | \mu \rangle$$

This factor is irrelevant if you are doing your own self-consistent calculations; it enters when you try to check someone else who chose $\mu_2 \otimes \mu_1$ instead of $\mu_1 \otimes \mu_2$.

{10} ⊗ {8} = {35} ⊕ {27} ⊕ {10} ⊕ {8}

* Four single coefficient tables are omitted; only the {27} is -1; the three with {35} are +1.



Multiplicity of 35; ● = 1, × = 2

Y = 1 I = 1/2 N

ξ_1 →	27 −	8 +
Δπ	$-\sqrt{5}/5$	$-2\sqrt{5}/5$
ΣK	$-2\sqrt{5}/5$	$\sqrt{5}/5$

Y = 1 I = 3/2 Δ

ξ_1 →	35 +	27 −	10 −
Δπ	1/4	$-\sqrt{5}/4$	$\sqrt{10}/4$
Δη	$\sqrt{5}/4$	3/4	$\sqrt{2}/4$
ΣK	$\sqrt{10}/4$	$-\sqrt{2}/4$	-1/2

Y = 0 I = 0 Λ

ξ_1 →	27 −	8 +
Σπ	$-\sqrt{10}/5$	$-\sqrt{15}/5$
ΞK	$-\sqrt{15}/5$	$\sqrt{10}/5$

Y = 0 I = 1 Σ

ξ_1 →	35 +	27 −	10 −	8 +
Σπ	$\sqrt{3}/6$	$-3\sqrt{5}/10$	$\sqrt{3}/3$	$-\sqrt{30}/15$
Ση	$\sqrt{2}/2$	$\sqrt{30}/10$	0	$-\sqrt{5}/5$
ΞK	$\sqrt{3}/3$	$-\sqrt{5}/5$	$-\sqrt{3}/3$	$\sqrt{30}/15$
ΔK̄	$\sqrt{3}/6$	$\sqrt{5}/10$	$\sqrt{3}/3$	$-2\sqrt{30}/15$

Y = 0 I = 2

ξ_1 →	35 +	27 −
Σπ	$\sqrt{3}/2$	-1/2
ΔK̄	1/2	$\sqrt{3}/2$

Y = -1 I = 1/2 Ξ

ξ_1 →	35 +	27 −	10 −	8 +
Ξπ	1/4	$-7\sqrt{5}/20$	$\sqrt{2}/4$	$-\sqrt{5}/5$
Ξη	3/4	$3\sqrt{5}/20$	$-\sqrt{2}/4$	$-\sqrt{5}/5$
ΩK	$\sqrt{2}/4$	$-3\sqrt{10}/20$	-1/2	$\sqrt{10}/5$
ΣK̄	1/2	$\sqrt{5}/10$	$\sqrt{2}/2$	$\sqrt{5}/5$

Y = -1 I = 3/2

ξ_1 →	35 +	27 −
Ξπ	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΣK̄	$\sqrt{2}/2$	$\sqrt{2}/2$

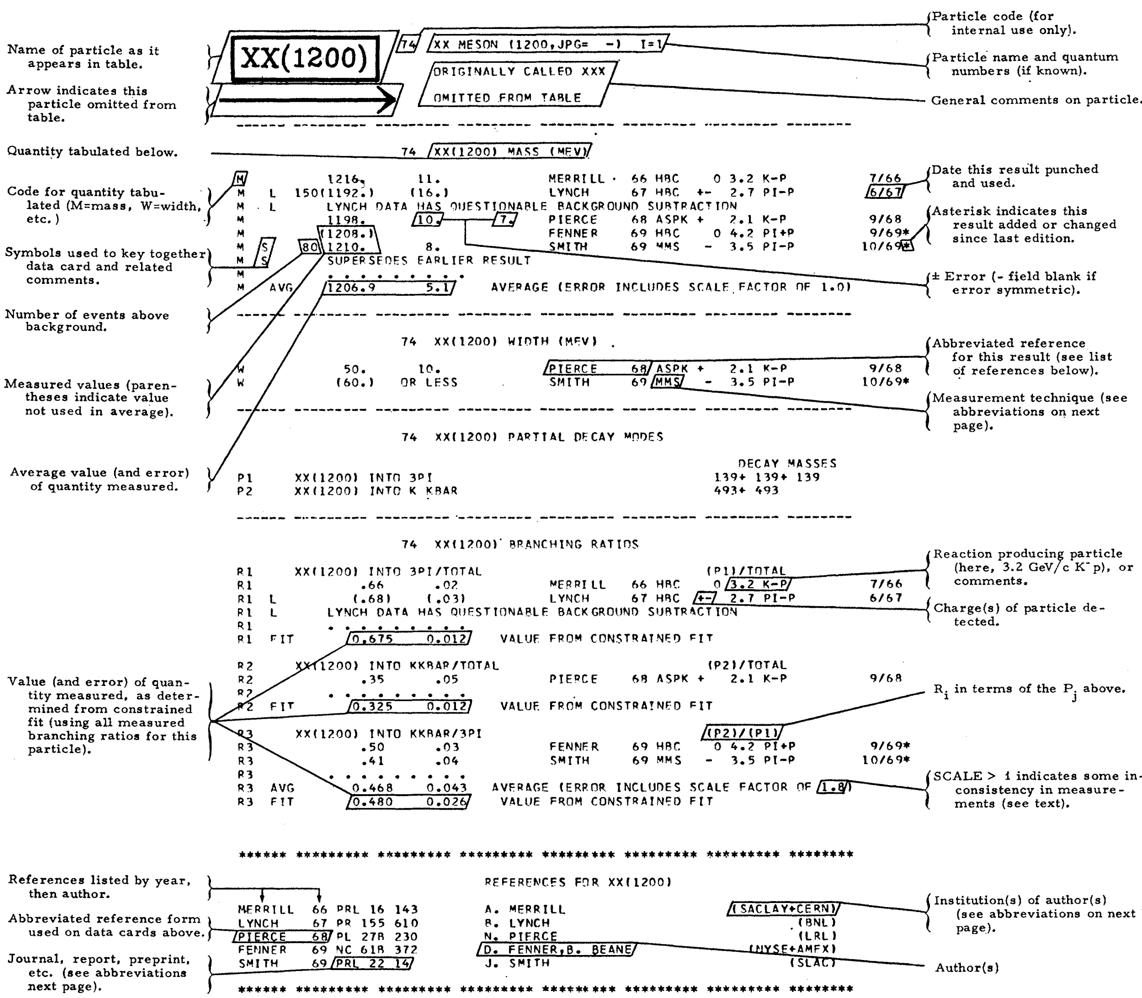
Y = -2 I = 0 Ω⁻

ξ_1 →	35 +	10 −
Ωη	$\sqrt{2}/2$	$-\sqrt{2}/2$
ΞK̄	$\sqrt{2}/2$	$\sqrt{2}/2$

Y = -2 I = 1

ξ_1 →	35 +	27 −
Ωπ	1/2	$-\sqrt{3}/2$
ΞK̄	$\sqrt{3}/2$	1/2

ILLUSTRATED KEY FOR DATA CARD LISTINGS



Explanation of Symbols and Abbreviations Used on the Data Cards

Measurement Technique (TECH)

CC	Cloud chamber
CNTR	Counters, electronics
EMUL	Emulsions
HBC	Hydrogen bubble chambers
HEBC	Helium bubble chambers
DBC	Deuterium bubble chambers
HLBC	Heavy liquid bubble chambers
OSPK	Optical spark chambers
ASPK	Automatic spark chambers
MMS	Missing mass spectrometer
RVUE	Review of previous experimental data

Journals

ADVP	Advances in Physics
ANP	Annals of Physics
ARNS	Annual Reviews of Nuclear Science
BAPS	Bulletin of the American Physical Society
JETP	English Translation of Soviet Physics JETP
NC	Nuovo Cimento
NP	Nuclear Physics
PL	Physics Letters
PPSL	Proceedings of the Physical Society of London
PR	Physical Review
PRL	Physical Review Letters
PRSL	Proceedings of the Royal Society of London
RMP	Reviews of Modern Physics
ZPHY	Zeitschrift für Physik

The following abbreviations refer to proceedings of Conferences.

AIX	International Conference on Elementary Particles, Aix-en-Provence, 1961
ARGONNE	International Conference on Weak Interactions, Argonne National Laboratory, 1965
ATHENS	Athens Topical Conference on Recently Discovered Resonant Particles, Ohio University, 1963
BALATON	Symposium on Weak Interactions, Balatonvilagos, Hungary, 1966
BERKELEY	International Conference on High Energy Physics, 1966
BNL	International Conference on Fundamental Aspects of Weak Interactions, Brookhaven National Laboratory, 1963
BOULDER	Symposium on Strong Interactions 1965
CERN	International Conference on High Energy Physics, 1958 and 1962
CORAL GABLES	Conference on Symmetry Principles at High Energy, 1964 and 1965
DESY	Internation Symposium on Electron and Photon Interactions at High Energies, Hamburg, 1965
DUBNA	International Conference on High Energy Physics, 1964
KIEV	Ninth Annual International Conference on High Energy Physics, 1959
OXFORD	International Conference on Elementary Particles, 1965
ROCH	Fifth (Sixth, Seventh) Annual Rochester Conference on High Energy Nuclear Physics 1955 (1956, 1957). Annual International Conference on High Energy Physics, Rochester, 1960.
SIENA	International Conference on Nucleon Structure, 1963.

Finally,

BNL	Brookhaven National Laboratory
CU	Columbia University, includes Nevis Reports
NYO	New York Operations Office, AEC
UCRL	Lawrence Radiation Laboratory (University of California)
etc.	refer to unpublished reports of the Author's Institution.

Since January 1969, when we have had to abbreviate an institutional name on the data and reference cards, we have used the following (which is the list used by the HERA group at CERN):

AACH	AACHEN,GERMANY	TECHNISCHE UNIV. AACHEN
AERE	HARWELL,BERKS,ENGL.	ATOMIC ENERGY RESEARCH ESTABLISHMENT
AMES	AMES ,IOWA,USA	IOWA STATE UNIV.
ANL	ARGONNE,ILL,USA	ARGONNE NAT. LAB
ANNA	ANN ARBOR,MICH,USA	UNIV. OF MICHIGAN
ARIZ	TUCSON,ARIZ,USA	UNIV.OF ARIZONA
ATEN	ATHENS,GREECE	NUCLEAR RESEARCH CENTRE DEMOKRITOS
ATHO	ATHENS,OHIO,USA	OHIO UNIV.
BARI	BARI ,ITALY	UNIV. DEGLI STUDI DI BARI
BELG	BRUXELLES,BELGIUM	INSTITUT INTERUNIVERSITAIRE DES SCIENCES NUCLEAIRES
BERG	BERGEN,NORWAY	FYSISK INSTITUTT
BERK	BERKELEY,CAL,USA	UNIV. OF CALIFORNIA
BERL	ZEUTHEN,BERLIN,GERM.	FORSCHUNGSSTELLE FUR PHYS. HOHER ENERGIEN DER DAW
BERN	BERN ,SWITZERLAND	UNIV. BERN
BGNA	BOLOGNA,ITALY	UNIV. DI BOLOGNA
BIRM	BIRMINGHAM,ENGLAND	BIRMINGHAM UNIV.
BNL	UPTON LI,NY,USA	BROOKHAVEN NAT. LAB.
BOHR	COPENHAGEN,DENMARK	NIELS BOHR INSTITUTE
BONN	BONN ,GERMANY	UNIV. BONN
BRAN	WALTHAM,MASS,USA	BRANDEIS UNIVERSITY
BROW	PROVIDENCE,RH.I,USA	BROWN UNIV.
BRUX	BRUXELLES,BELGIUM	UNIV. LIBRE DE BRUXELLES
BUFF	BUFFALO,NY,USA	STATE UNIV. OF NEW YORK AT BUFFALO
CAEN	CAEN ,FRANCE	LAB. DE PHYS. CORPUSCULAIRE
CALT	PASADENA,CAL,USA	CALIFORNIA INST. OF TECHNOLOGY
CARN	PITTSBURGH,PA,USA	CARNEGIE INST. OF TECHNOLOGY
CASE	CLEVELAND,OHIO,USA	CASE WESTERN RESERVE UNIV.
CAVE	CAMBRIDGE,ENGLAND	CAVENDISH LAB.,CAMBRIDGE UNIV.
CCNY	NEW YORK,NY,USA	CITY COLL. OF THE CITY OF NEW YORK
CDEF	PARIS ,FRANCE	COLLEGE DE FRANCE
CEA	CAMBRIDGE,MASS,USA	CAMBRIDGE ELECTRON ACCELERATOR
CERN	GENEVA,SWITZERLAND	EUROPEAN ORGANISATION FOR NUCL. RESEARCH
CHIC	CHICAGO,ILL,USA	UNIV. OF CHICAGO
COLO	BOULDER,COL,USA	UNIV. OF COLORADO
COLU	NEW YORK,NY,USA	COLUMBIA UNIV.
CORN	ITHACA,NY,USA	CORNEL UNIV.
DARE	DARESBURY,ENGLAND	DARESBURY NUCL. PHYS. LAB.
DESY	HAMBURG,GERMANY	DEUTSCHES ELEKTRONEN-SYNCHROTRON
DUKE	DURHAM,NC,USA	DUKE UNIV.
DURH	DURHAM,ENGLAND	UNIV. OF DURHAM
EFIN	CHICAGO,ILL,USA	ENRICO FERMI INST. FOR NUCL. STUDIES
EPOL	PARIS ,FRANCE	ECOLE POLYTECHNIQUE
ETHZ	ZURICH,SWITZERLAND	EIDGENOSSISCHE TECHNISCHE HOCHSCHULE
FIRZ	FIRENZE,ITALY	UNIV. DI FIRENZE
FLAS	TALLAHASSEE,FLA,USA	FLORIDA STATE UNIV.
FLOR	GAINESVILLE,FLA,USA	UNIV. OF FLORIDA
FRAS	FRASCATI,ITALY	LABORATORI NAZIONALI DEL SINCROTRONE
GENO	GENOVA,ITALY	UNIV. DI GENOVA
GEVA	GENEVA,SWITZERLAND	UNIV. DE GENEVE
GLAS	GLASGOW,SCOTLAND	UNIV. OF GLASGOW
GRAZ	GRAZ ,AUSTRIA	UNIV. GRAZ
HAMB	HAMBURG,GERMANY	UNIV. HAMBURG
HARV	CAMBRIDGE,MASS,USA	HARVARD UNIV.
HAWA	HONOLULU,HAWAII,USA	UNIV. OF HAWAII
HEID	HEIDELBERG,GERMANY	UNIV. HEIDELBERG
HELS	HELSINKI,FINLAND	HELSINGIN YLIOPISTO
ILL	URBANA,ILL,USA	UNIV. OF ILLINOIS
IND	BLOOMINGTON,IND,USA	UNIV. OF INDIANA
IOWA	IOWA CITY,IOWA,USA	UNIV. OF IOWA
IPN	ORSAY ,FRANCE	INST. DE PHYS. NUCLEAIRE
IRAD	PARIS ,FRANCE	INSTITUTE DU RADIUM
IRVN	IRVINE,CAL,USA	UNIV. OF CALIFORNIA
ITEP	MOSCOW,USSR	INST. FOR THEOR. AND EXPERIM. PHYS.
JHOP	BATIMORE,MD,USA	JOHNS HOPKINS UNIVERSITY
JINR	DUBNA ,USSR	JOINT INST. FOR NUCL. RESEARCH
KARL	KARLSRUHE,GERMANY	TECHNISCHE UNIV. KARLSRUHE
KRAK	KRAKOW,POLAND	JAGELLONIAN UNIV.
LANC	LANCASTER,ENGLAND	LANCASTER UNIV.
LEBD	MOSCOW,USSR	LEBEDEV PHYSICS INSTITUTE
LEID	LEIDEN,NETHERLANDS	INST. LORENTZ
LIVP	LIVERPOOL,ENGLAND	LIVERPOOL UNIV.
LOIC	LONDON,ENGLAND	IMPERIAL COLL. OF SCIENCE AND TECHNOLOGY
LOUC	LONDON,ENGLAND	UNIV. COLL.
LOUI	BATON ROUGE,LA,USA	LOUISIANA STATE UNIV.
LRL	BERKELEY,CAL,USA	LAWRENCE RADIATION LAB.,UNIV. OF CALIFORNIA
LUND	LUND ,SWEDEN	UNIV. I LUND
MADR	MADRID,SPAIN	JUNTA DE ENERGIA NUCLEAR
MANH	NEW YORK,NY,USA	MANHATTAN COLL.
MANZ	MAINZ ,GERMANY	UNIV. MAINZ
MASS	AMHERST,MASS,USA	UNIV.OF MASSACHUSETTS
MCGI	MONTREAL,CANADA	MC GILL UNIV.
MCHS	MANCHESTER,ENGLAND	UNIV. OF MANCHESTER
MICH	EAST LANSING,MI,USA	MICHIGAN STATE UNIV.
MILA	MILANO,ITALY	UNIV. DI MILANO
MIT	CAMBRIDGE,MASS,USA	MASSACHUSETTS INST. OF TECHNOLOGY
MPIM	MUNICH,GERMANY	MAX-PLANCK-INST. FUR PHYSIK UND ASTROPHYSIK
NAL	OAK BROOK,ILL,USA	NATIONAL ACCELERATOR LAB.
NAPL	NAPOLI,ITALY	UNIV. DI NAPOLI
NDAM	NOTRE DAME,IND,USA	NOTRE DAME UNIV.
NEAS	BOSTON,MASS,USA	NORTHEASTERN UNIV.
NEVI	IRVINGTON-ON-HUDSON	NEVIS LABS,NY,USA
NIJM	NIJMEGEN,NETHERLAND	R.K. UNIV. NIJMEGEN
NOVO	NOVOSIBIRSK,USSR	INST. OF NUCL. PHYS.
NWES	EVANSTON,ILL,USA	NORTHWESTERN UNIV.
NYU	NEW YORK,NY,USA	NEW YORK UNIV.
OHIO	COLUMBUS,OHIO,USA	OHIO STATE UNIV.
OREG	EUGENE,ORE,USA	UNIV. OF OREGON
ORNL	OAK RIDGE,TENN,USA	OAK RIDGE NAT. LAB.
ORSA	ORSAY ,FRANCE	UNIV. DE PARIS, FACULTE DES SCIENCES
ORUC	OAK RIDGE,TENN,USA	UNION CARBIDE NUCL. DIVISION
OSLO	OSLO ,NORWAY	OSLO UNIV.
OTTA	OTTAWA,CANADA	NATIONAL RESEARCH COUNCIL
OXF	OXFORD,ENGLAND	OXFORD UNIV.
PADO	PADOVA,ITALY	UNIV. DI PADOVA
PENN	PHILADELPHIA,PA,USA	UNIV. OF PENNSYLVANIA
PISA	PISA ,ITALY	UNIV. DI PISA
PITT	PITTSBURGH,PA,USA	UNIV. OF PITTSBURGH
PPPA	PRINCETON,NJ,USA	PRINCETON-PENNSYLVANIA PROTON ACCELERATOR
PRIN	PRINCETON,NJ,USA	PRINCETON UNIV.
PURD	LAFAYETTE,IND,USA	PURDUE UNIV.
REHO	REHOVOTH,ISRAEL	WEIZMANN INST. OF SCIENCE
RHEL	CHILTON,DIDCOT,BERKS	RUTHERFORD HIGH ENERGY LAB. (ENGLAND).
RISO	ROSKILDE,DENMARK	RESEARCH ESTABLISHMENT RISO
RIVS	RIVERSIDE,CAL,USA	UNIV. OF CALIFORNIA
ROCH	ROCHESTER,NY,USA	UNIV. OF ROCHESTER
ROMA	ROME ,ITALY	UNIV. DEGLI STUDI DI ROMA
RUTG	NEW BRUNSWICK,NJ,USA	RUTGERS UNIV.
SACL	SACLAY,GIF-S-YVETTE	CENTRE D'ETUDES NUCLEAIRES SACLAY (FRANCE)
SERP	SERPUKHOV,USSR	INST. OF HIGH ENERGY PHYS.
SHAM	SOUTHAMPTON,ENGLAND	UNIV. OF SOUTHAMPTON
SLAC	STANFORD,CAL,USA	STANFORD LINEAR ACCELERATOR CENTER
STAN	STANFORD,CAL,USA	STANFORD UNIV.
STEV	HOBOKEN,NJ,USA	STEVENS INST. OF TECHNOLOGY
STLO	ST LOUIS,MO,USA	WASHINGTON UNIV.
STOH	STOCKHOLM,SWEDEN	STOCKHOLMS UNIV.
STON	STONY BROOK,LI,NY	STATE UNIV. OF NEW YORK AT STONY BROOK (USA)
STRB	STRASBOURG,FRANCE	CENTRE DES RECHERCHES NUCLEAIRES
SUSS	SUSSEX,ENGLAND	SUSSEX UNIV.
SYR	SYRACUSE,NY,USA	SYRACUSE UNIV.
TENN	KNOXVILLE,TENN,USA	UNIV. OF TENNESSEE
TNTO	TORONTO,CANADA	UNIV. OF TORONTO
TORI	TORINO,ITALY	UNIV. DI TORINO
TRST	TRIESTE,ITALY	UNIV. DI TRIESTE
TUFT	MEDFORD,MASS,USA	TUFTS UNIV.
UCLA	LOS ANGELES,CAL,USA	UNIV. OF CALIFORNIA
UCSB	SANTA BARBARA,CAL	UNIV. OF CALIFORNIA (USA)
UCSC	SANTA CRUZ,CAL,USA	UNIV. OF CALIFORNIA
UCSD	LA JOLLA,CAL,USA	UNIV. OF CALIFORNIA,SAN DIEGO
UMD	COLLEGE PARK,MD,USA	UNIV. OF MARYLAND
UTAH	SALT LAKE CITY,UTAH	UNIV. OF UTAH (USA)
VAND	NASHVILLE,TENN,USA	VANDERBILT UNIV.
WARS	WARSAW,POLAND	UNIV. OF WARSAW
WASH	SEATTLE,WAS,USA	UNIV. OF WASHINGTON
WIEN	WIEN ,AUSTRIA	UNIV. WIEN
WISC	MADISON,WIS,USA	UNIV. OF WISCONSIN
YALE	NEW HAVEN,CONN,USA	YALE UNIVERSITY

DATA CARD LISTINGS

STABLE PARTICLES

I.E. IMMUNE TO STRONG DECAY

Data in parentheses have not been included in our averages.

```
CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE
   ABOVE                                                            PUNCHED
 BACKGROUND
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γ

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                     0 GAMMA (0,J=1)

                 0  GAMMA MASS  (IN UNITS OF 10**-21 MEV)

M            (6.)   OR LESS              PATEL     65          SATELLITE DATA   10/69*
M            (6.)   OR LESS              GINTSBURG 64          SATELLITE DATA   10/69*
M            (2.3)  OR LESS              GOLDHABER 68          SATELLITE DATA   10/69*

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                          REFERENCES

                          0  GAMMA

GINTSBUR 64 SOV. ASTR.AJ7 536 M. A. GINTSBURG               (ACAD SCI,USSR)
PATEL    65  PL   14  105     V. L. PATEL                          (DURHAM)
GOLDHABE 68  PRL  21  567     A. GOLDHABER,M. NIETO           (STONY BROOK)

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ν_e

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                   1  E-NEUTRINO  (0,J=1/2)

                   1  E-NEUTRINO  MASS (KEV)

M      LESS THAN              0.25    LANGER    52 CNTR
M      LESS THAN              0.15    HAMILTON  53 CNTR
M      LESS THAN    0.55 +OR- 0.28    FRIEDMAN  58 CNTR
M      LESS THAN              0.06    BERGKVIST 69 CNTR   EL.STATIC.MAG.SP 11/69*

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                          REFERENCES

                          1  E-NEUTRINO  (0,J=1/2)

LANGER   52 PR   88  689      L M LANGER,R J D MOFFAT              (INDIANA)
HAMILTON 53 PR   92  1521     D HAMILTON,W P ALFORD,L GROSS     (PRINCETON)
FRIEDMAN 58 PR 109  2214      LEWIS FRIEDMAN,LINCOLN G SMITH          (BNL)
BERGKVIS 69 CERN 69-7 91      KARL-ERIK BERGKVIST          (UNIV STOCKHOLM)

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ν_μ

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                   2  MU-NEUTRINO  (0,J=1/2)

                   2  MU-NEUTRINO  MASS (MEV)

M            (3.5)  OR LESS              BARKAS    56 EMUL
M            (4.0)  OR LESS              DUDZIAK   59 CNTR
M            (3.6)  OR LESS              FEINBERG  63 RVUE                    7/66
M            (3.0)  OR LESS              ALLCOCK   65 RVUE                    7/66
M            (2.5)  OR LESS              BARDON    65 ASPK
M            (2.1)  OR LESS              SHAFER    65 CNTR  CONF LEV = 68PCT  7/66
M            (1.6)  OR LESS              BOOTH     67 CNTR   90 PERCNT C.L.   3/68
M            (2.2)     OR LESS,CL=0.90 HYMAN     67 HEBC   0. K- HE        11/67
M            (0.46)    (0.64)    (0.46) FRANK     68 CNTR    C.L.=0.67       9/68

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                          REFERENCES
                          2  MU-NEUTRINO  (0,J=1/2)

BARKAS   56 PR 101  778       W H BARKAS,W BIRNBAUM,F M SMITH          (LRL)
DUDZIAK  59 PR 114  336       W F DUDZIAK,R SAGANE,J VEDDER            (LRL)
FEINBERG 63 ARNS 13 431       G FEINBERG, L M LEDERMAN            (COLUMBIA)
ALLCOCK  65 PPSL  85  875     G R ALLCOCK                        (LIVERPOOL)
BARDON   65 PRL  14 449       BARDON,NORTON,PEOPLES + (COLUM+STONY BROOK)

SHAFER   65 PRL  14 923       R E SHAFER,CROWE,JENKINS                 (LRL)
BOOTH    67 PL 268  39        BOOTH,JOHNSON,WILLIAMS,WORMALD  (LIVERPOOL)
HYMAN    67 PL 25 B 376       +LOKEN,PEWITT,MCKENZIE,KEYES+(ARG+CARN+NWU)
FRANK    68  VIENNA ABS.  365 FRANK,GAMET,LAKIN            (SHAM+LIVP+STAN)

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e

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                 3  ELECTRON  (0.5,J=1/2)

                 3  ELECTRON  MASS (MEV)

M          0.511006 0.000002          COHEN      65 RVUE

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           3  ELECTRON LIFETIME (UNITS 10**21 YR)

T          OVER                 2.0   MOE        65 CNTR                     6/66

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                 3  ELECTRON MAGNETIC MOMENT(E/2ME)

MM         (1.0011609X.0000024)       SCHUPP     61 CNTR  -
MM   R     (1.001159622) +-(27)*10**-9 WILKINSON 63 CNTR  -                  8/66
MM         (1.001168) (.000011)       RICH       66 CNTR  +  POSITRON        8/66
MM         (1.001159557) +-(30)*10**-9 RICH      68 CNTR  -                  6/68
MM   R RICH 68 IS REEVALUATION OF WILKINSON 63

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                          REFERENCES
                          3  ELECTRON  (0.5,J=1/2)

SCHUPP   61 PR  121   1       A A SCHUPP,R W PIDD,H R CRANE      (MICHIGAN)
WILKINSO 63 PR 130 852        D T WILKINSON,H R CRANE             (MICHIGAN)
COHEN    65 RMP 37 537        E R COHEN, J W M DUMOND       (NAASC+CALTECH)
MOE      65 PR 140 B 992      M K MOE,F REINES      (CASE INST TECHNOLOGY)
RICH     66 PRL  17  271      A RICH, H R CRANE                   (MICHIGAN)
RICH     68 PRL 20 967        A RICH                              (MICHIGAN)

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μ

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                   4  MUON  (106,J=1/2)

                   4  MUON  MASS (MEV)

M           105.659    0.002            FEINBERG  63 RVUE
M          . . . . . . . . .
M    FIT    105.659    0.002    VALUE FROM CONSTRAINED FIT                   6/68

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                   4  MUON LIFETIME (UNITS 10**-6)

T             2.198    0.001    0.001 FARLEY    62 CNTR
T             2.203    0.004          LUNDY     62 CNTR   CONLEV=.98        11/67
T             2.202    0.003    0.003 ECKHAUSE  63 CNTR
T             2.197    0.002    0.002 MEYER     63 CNTR +
T             2.198    0.002    0.002 MEYER     63 CNTR -                    7/66
T          . . . . . . . . .
T    AVG     2.1983    0.0008   0.0008  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                   4  RATIO OF LIFETIME OF MU+ TO MU-

DT            1.000    0.001            MEYER     63 CNTR  LIFETIME MU+/MU-   7/66

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                   4  MUON PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     MUON INTO E (E-NEU) (MU-NEU)                       .5+   0+    0
P2     MUON INTO E 2GAMMA                                 .5+   0+    0
P3     MUON INTO 3ELECTRONS                               .5+  .5+   .5
P4     MUON INTO E GAMMA                                  .5+   0

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                   4  MUON  BRANCHING RATIOS

R1     MUON INTO  E+2GAMMA  (IN UNITS OF 10**-5)          (P2)/(P1)
R1            (1.6)OR LESS  C.L.= .90  FRANKEL1  63 OSPK

R2     MUON INTO 3E (IN UNITS OF 10**-7)                  (P3)/(P1)
R2 F          (5.0)OR LESS  C.L.= .90  PARKER    62 CNTR
R2 F          (1.3)OR LESS  C.L.= .90  ALIKHANOV 62 OSPK
R2 F          (1.5)OR LESS  C.L.= .90  FRANKEL2  63 CNTR
R2 F          (1.25)OR LESS C.L.= .90  BABAEV    63 OSPK
R2 F FOUR ABOVE EXPERIMENTS EVALUATED UPPER LIMITS ASSUMING A SECOND ORDER
R2    V-A NEUTRINO LOOP DIAGRAM. LIMITS NOT SIGINFICANTLY CHANGED BY
R2    ASSUMING A CONSTANT MATRIX ELEMENT.

R3     MUON INTO  E+GAMMA  (IN UNITS OF 10**-8)           (P4)/(P1)
R3            (4.3)OR LESS  C.L.= .90  FRANKEL1  63 OSPK
R3            (2.2)OR LESS  C.L.= .90  PARKER    64 OSPK

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                   4  MUON ANOMALOUS MAGN. MOMENT (10**-6*E/(2*MUON MASS))

MM          1162.0      5.0             CHARPAK   62 CNTR +
MM   B     (1165.75)   (0.71)           BAILEY    68 CNTR +  STOR. RINGS     5/69*
MM   B     (1166.25)   (0.24)           BAILEY    68 CNTR -  STOR. RINGS     5/69*
MM   B      ERRORS STATISTICAL. VALUES COMBINED TO GIVE MU+- VALUE BELOW    5/69*
MM          1166.16     0.31            BAILEY    68 CNTR +- STOR. RINGS     5/69*
MM          . . . . . . . . .
MM   AVG    1166.14     0.31    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                   4  MUON DECAY PARAMETERS

RHO         RHO PARAMETER            (V-A THEORY PREDICTS RHO=0.75)
RHO C        (0.741)  (0.027)          DUDZIAK   59 CNTR +  20-53 MEV E+    10/69*
RHOP  9213    0.745    0.025           PLANO     60 HBC  +  WHOLE SPECTRUM  10/69*
RHOP        TWO PARAMETER FIT TO RHO AND ETA
RHO C 2276   (0.751)  (0.034)          BLOCK     62 HEBC -  WHOLE SPECTRUM  10/69*
RHO D        (0.64)   (0.04)           BARLOW    64 CNTR -  WHOLE SPECTRUM  10/69*
RHO D        (0.661)  (0.016)          BARLOW    64 CNTR +  WHOLE SPECTRUM  10/69*
RHO D        (0.867)  (0.035)          PONTECORV 64 CC   -                  10/69*
RHO D       RESULTS IN DOUBT                                                10/69*
RHO C 800K   (0.7503) (0.0026)         PEOPLES   66 ASPK +  20-53 MEV E+    10/69*
RHO C 280K   (0.760)  (0.009)          SHERWOOD  67 ASPK +  25-53 MEV E+    10/69*
RHO C 170K   (0.762)  (0.008)          FRYBERGER 68 ASPK +  25-53 MEV E+    10/69*
RHO C       ETA CONSTRAINED =0. THESE VALUES INCORPORATED INTO A TWO        10/69*
RHO C       PARAMETER FIT TO RHO AND ETA BY DERENZO 69.
RHO           0.7518   0.0026          DERENZO   69 RVUE                    10/69*
RHO         . . . . . . . . .
RHO AVG       0.7517   0.0026  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

ETA         ETA PARAMETER            (V-A THEORY PREDICTS ETA=0)
ETA P 9213   (-2.0)    (0.9)           PLANO     60 HBC  +  WHOLE SPECTRUM  10/69*
ETA P   TWO PARAMETER FIT TO RHO AND ETA- PLANO 60 DISCOUNTS VALUE FOR ETA  10/69*
ETA C 800K   (0.05)    (0.5)           PEOPLES   66 ASPK +  20-53 MEV E+    10/69*
ETA C 280K   (-0.7)    (0.6)           SHERWOOD  67 ASPK +  25-53 MEV E+    10/69*
ETA C 170K   (-0.7)    (0.5)           FRYBERGER 68 ASPK +  25-53 MEV E+    10/69*
ETA C       RHO CONSTRAINED =0.75
ETA   6346   -0.12     0.21            DERENZO   69 HBC  +  1.6-6.8 MEV E+  10/69*
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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XSI          XSI PARAMETER           (V-A THEORY PREDICTS XSI=1)
XSI     9K     0.97      0.05 .        BARDON     59 CNTR    BROMOFORM TARGET 10/69*
XSI   8354     0.93      0.06          PLANO      60 HBC  +  8.8 KGAUSS       10/69*
XSI A         (0.903)   (0.027)        ALI-ZADE   61 EMUL +  27 KGAUSS        10/69*
XSI A        DEPOLARIZATION BY MEDIUM NOT KNOWN SUFFICIENTLY WELL             10/69*
XSI G  66K    (0.975)   (0.030)        GUREVICH   64 EMUL    140 KGAUSS       10/69*
XSI            0.975     0.014         GUREVICH   67 EMUL                     10/69*
XSI G        GUREVICH 67 SUPERCEEDS GUREVICH 64                               10/69*
XSI          . . . . . . . . . .
XSI AVG        0.972     0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

DEL          DELTA PARAMETER         (V-A THEORY PREDICTS DELTA=0.75)
DEL   8354     0.78      0.05          PLANO      60 HBC  +  WHOLE SPECTRUM   10/69*
DEL            0.782     0.031         KRUGER     61                          10/69*
DEL   490K     0.752     0.009         FRYBERGER 68 ASPK +  25-53 MEV E+      10/69*
DEL                 VOSSLER 69 HAS MEASURED THE ASYMMETRY BELOW 10 MEV        11/69*
DEL          . . . . . . . . . .
DEL AVG        0.7551    0.0085  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

HEL          HELICITY OF DECAY ELECTRON
HEL          (V-A THEORY PREDICTS HELICITY=+-1 FOR E+-, RESPECIVELY)
HEL          WE HAVE FLIPPEC THE SIGN FOR E- SO OUR PROGRAMS CAN AVERAGE
HEL D         (0.28)    (0.16)         DICK       63 CNTR +  ANNIHILATION     10/69*
HEL D        IN DOUBT- POSITRONS POSSIBLY DEPOLARIZED IN BE MODERATOR         10/69*
HEL            1.05      0.30          BUHLER     63 CNTR +  ANNIHILATION     10/69*
HEL            0.94      0.38          BLOOM      64 CNTR +  BREMS TRANSMISS  10/69*
HEL            1.04      0.18          DUCLOS     64 CNTR +  BHABHA SCATT     10/69*
HEL    29K     0.89      0.28          SCHWARTZ   67 OSPK -  MOLLER SCATT     10/69*
HEL          . . . . . . . . . .
HEL AVG        1.00      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

GS           SCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GS            (0.33)  OR LESS          DERENZO    69 RVUE                     10/69*

GA           AXIALVECTOR COUPLING CONSTANT IN MUON DECAY   (IN UNITS OF GV)
GA             0.86      0.33     0.11 DERENZO    69 RVUE                     10/69*

FAV          PHASE BETWEEN VECTOR AND AXIALVECTOR COUPLINGS    (DEGREES)
FAV           180.       15.           DERENZO    69 RVUE                     10/69*

GT           TENSOR COUPLING CONSTANT IN MUON DECAY    (IN UNITS OF GV)
GT            (0.28)  OR LESS          DERENZO    69 RVUE                     10/69*

GP           PSEUDOSCALAR COUPLING CONSTANT IN MUON DECAY  (IN UNITS OF GV)
GP            (0.33) OR LESS           DERENZO    69 RVUE                     10/69*

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                              REFERENCES
                              4  MUON  (106,J=1/2)

BARDON    59  PRL  2   56      M BARDON, D BERLEY, L LEDERMAN   (COLUMBIA)
DUDZIAK   59  PR 114  336      W DUDZIAK,R SAGANE, J VEDDER          (LRL)
PLANO     60  PR 119 1400      R J PLANO                        (COLUMBIA)
ALI-ZADE  61  JETP 40  452     ALI-ZADE,GUREVICH,NIKOLSKI           (USSR)
KRUGER    61  UCRL-9322 (UNPUB) H KRUGER                             (LRL)

ALIKHANO  62  CERN CONF 423    A I ALIKHANOV,A BABAEV +      (ITEP MOSCOW)
BLOCK     62  NC  23 1114      BLOCK,FIORINI,KIKUCHI+(DUKE,BOLOGNA,MILANO)
CHARPAK   62  PL   1   16      G CHARPAK,F J M FARLEY,R L GARWIN +  (CERN)
FARLEY    62  CERN CONF 415    FARLEY,MASSAM,MULLER,ZICHICHI        (CERN)
LUNDY     62  PR 125 1686      RICHARD A LUNDY                     (EFINS)
PARKER    62  NC  23  485      S PARKER,S PENMAN                   (EFINS)

BABAEV    63  JETP 16 1397     BABAEV,BALATS,KAFTANOV,LANDSBERG +   (ITEP)
BUHLER    63  PL   7  368      +CABIBBO,FIDECARO,MASSAM,MULLER+     (CERN)
DICK      63  PL   7  150      DICK,FEUVRAIS,SPIGHEL                (CERN)
ECKHAUSE  63  PR 132  422      M ECKHAUSE,T A FILIPPAS +        (CARNEGIE)
FRANKEL1  63  NC  27  894      S FRANKEL,W FRATI,J HALPERN +       (PENNA)
FRANKEL2  63  PR 130  351      S FRANKEL,W FRATI,J HALPERN +       (PENNA)
MEYER     63  PR 132  2693     S L MEYER,ANDERSON,BLESER,LEDERMAN+ (COLUM)

BARLOW    64  PPS  84  239     +BOOTH,CARROL,COURT,DAVIES,EDWARDS+  (LIVP)
BLOOM     64  PL   8   87      +DICK,FEUVRAIS,HENRY,MACQ,SPIGHEL    (CERN)
DUCLOS    64  PL   9   62      +HEINTZE,DE PUJULA,SOERGEL           (CERN)
GUREVICH  64  PL  11  185      GUREVICH,MAKARIYNA+    (KURCHATOV,MOSCOW)
PONTECOR  64  DUBNA CONF       PONTECORVO,SULYAEV                 (MOSCOW)
PARKER    64  PR 1338 768      S PARKER,H L ANDERSON,C REY         (EFINS)

PEOPLES   66  NEVIS-147 (UNPUB) J PEOPLES                       (COLUMBIA)
GUREVICH  67  IAE 1297         GUREVICH,MAKARIYNA,MISHAKOVA+   (KURCHATOV)
SCHWARTZ  67  PR 162 1306      D M SCHWARTZ                        (EFINS)
SHERWOOD  67  PR 156 1475      B A SHERWOOD                        (EFINS)
BAILEY    68  PL  28B  287     +BARTL,VON BOCHMANN,BROWN,FARLEY+    (CERN)
FRYBERGE  68  PR 166 1379      D FRYBERGER                         (EFINS)
DERENZO   69  PR 181 1854      S DERENZO                           (EFINS)
VOSSLER   69  NC 63A 423       C VOSSLER                           (EFINS)

                    PAPERS NOT REFERRED TO IN DATA CARDS

FISHER    59  PRL  3  349      FISHER,LEONTIC,LUNDBY,MEUNIER,STROOT (CERN)
ASTBURY   60  ROCH CONF 60 542 ASTBURY,HATTERSLEY,HUSSAIN +    (LIVERPOOL)
DEVONS    60  PRL  5  330      DEVONS,GIDAL,LEDERMAN,SHAPIRO    (COLUMBIA)
LATHROP   60  NC   17 109      J LATHROP,R A LUNDY,V L TELEGDI +   (EFINS)
LATHROP   60  NC   17 114      J LATHROP,R A LUNDY,S PENMAN +      (EFINS)
REITER    60  PRL  5   22      REITER,ROMANOWSKI,SUTTON +       (CARNEGIE)
TELEGDI   60  ROCH CONF 60 713 V L TELEGDI                          (CERN)
CHARPAK   61  PRL  6  128      CHARPAK,FARLEY,GARWIN,MULLER,SENS +  (CERN)
HUTCHINS  61  PRL  7  129      D P HUTCHINSON,J MENES +         (COLUMBIA)
SHAPIRO   62  PR 125 1022      G SHAPIRO,L M LEDERMAN           (COLUMBIA)
FEINBERG  63  ARNS 13 431      GERALD FEINBERG, L M LEDERMAN    (COLUMBIA)
FAIRLEY   66  NC 45A 281       FAIRLEY,BAILEY,BROWN,GIESCH +        (CERN)
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              8  CHARGED PION  (140,JPG=0--)  I=1

              8  CHARGED PI  MASS (MEV)

M             139.37    0.20          CROWE      54 CNTR  -
M             139.68    0.15          BARKAS     56 EMUL  +
M             139.577   0.013         SHAFER     67 CNTR    MESONIC ATOMS      6/68
M             . . . . . . . . . .
M   AVG       139.577   0.013   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT       139.578   0.013   VALUE FROM CONSTRAINED FIT                     6/68

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              8  PI+ MU+ MASS DIFFERENCE (MEV)

D              34.00    0.076         BARKAS     56 EMUL
D              33.89    0.076         BARKAS     56 EMUL
D             . . . . . . . . . .
D   AVG        33.945   0.055   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   FIT        33.920   0.013   VALUE FROM CONSTRAINED FIT                     6/68
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                       8  CHAR.PI LIFETIME (UNITS 10**-9)

T               25.6     0.5     0.5   CROWE     57 RVUE
T               25.6     0.8     0.8   ANDERSON  60 CNTR
T        8000   25.46    0.32    0.32  ASHKIN    60 CNTR +
T                                      MERRISON  62 RVUE
T               26.02    0.04          ECKHAUSE  65 CNTR +                  9/66
T               25.6     0.3           BARDON    66 CNTR                    6/66
T               25.9     0.3           DUNAITSEV 66 CNTR                    6/68
T    N         (26.40)  (0.08)         KINSEY    66 CNTR +                  6/66
T    N   SYSTEMATIC ERRORS IN CALIBR.IN THIS EXP. DISCUSSED BY NORDBERG 67  8/67
T               26.67    0.24          LOBKOWICZ 66 CNTR                    9/66
T              (26.6)   (0.2)          AYRES     67 CNTR    OLD,RETRACTED  11/69*
T               26.04    0.05          NORDBERG  67 CNTR +                  8/67
T    A         (25.97)  (0.04)         AYRES     69 CNTR  - NEW EXPT.      11/69*
T    A                              AYRES PI- LIFETIME IS PRELIMINARY      11/69*
T              . . . . . . . . . .
T    AVG        26.027   0.060   0.059   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
                         (SEE IDEOGRAM BELOW )
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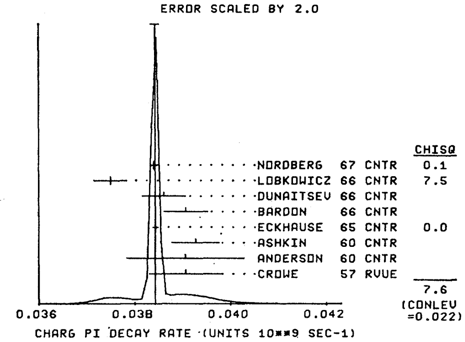
WEIGHTED AVERAGE = 0.038422 ± 0.000088
ERROR SCALED BY 2.0

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              8 MEANLIFE DIFFERENCE,(+)-(-)/AVGE. (PERCENT)

DT  N    THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT            0.23      0.40          LOBKOWICZ 66 CNTR     SEE NOTE L     9/66
DT  L    ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS             9/66
DT            0.4       0.7           BARDON    66 CNTR                    7/66
DT           (0.56)    (0.28)         AYRES     67 CNTR    OLD,RETRACTED  10/66
DT           -0.14      0.29          PETRUKHIN 68 CNTR                    8/68
DT            0.055     0.071         AYRES     69 CNTR    NEW EXPT       10/69*
DT           . . . . . . . . . .
DT  AVG       0.053     0.068   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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              8  CHARGED PION PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      CHAR.PION INTO MU (MU-NEU)                       105+   0
P2      CHAR.PION INTO E (E-NEU)                          .5+   0
P3      CHAR.PION INTO MU (MU-NEU) GAMMA                 105+   0+    0
P4      CHAR.PION INTO PIO E (E-NEU)                     134+  .5+    0
P5        CHAR.PION INTO E NEU GAMMA                      .5+   0+    0

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              8  CHARGED PION BRANCHING PATIOS

R1      CHAR.PION INTO MU NEU GAMMA  (UNITS 10**-4)       (P3)/(P1)
R1       26     1.24      0.25            CASTAGNOL 58 EMUL    E(MU).LT.3.38 MV

R2      CHAR.PION INTO E NEU          (UNITS 10**-4)       (P2)/(P1)
R2              1.21      0.07            ANDERSON  60 CNTR
R2              1.247     0.028           DI CAPUA  64 CNTR
R2           . . . . . . . . . .
R2  AVG         1.242     0.026   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R3      CHAR.PION INTO PIO E NEU      (UNITS 10**-8)       (P4)/(P1)
R3       36     0.97      0.20            BARTLETT  64 OSPK
R3       38     1.07      0.21            BACASTOW  65 OSPK +
R3              1.10      0.26            BERTRAM   65 OSPK                  6/66
R3       43     1.1       0.2             DUNAITSEV 65 CNTR                  7/66
R3      332     1.00      0.08      0.10  DEPOMMIER 68 CNTR                  3/68
R3           . . . . . . . . . .
R3  AVG         1.023     0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4        CHAR.PION INTO E NEU GAMMA (UNITS 10**-8)        (P5)/(P1)
R4      143     3.0       0.5             DEPOMMIER 63 CNTR    GAM KE 50-90 MEV  6/66

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                              REFERENCES
                              8 CHARGED PION (140,JPG=0--)I=1

CROWE     54 PR  96  470       K M CROWE,R H PHILLIPS                 (LRL)
BARKAS    56 PR 101  778       W H BARKAS,W BIRNBAUM,F M SMITH        (LRL)
CROWE     57 NC   5  541       K M CROWE                    (STANFORD HEPL)
CASTAGNO  58 PR 112 1779       C CASTAGNOLI,M MUCHNIK            (ROME I F)

ANDERSON  60 PR 119 2050       H L ANDERSON,T FUJII,R H MILLER +    (EFINS)
ASHKIN    60 NC  16  490       ASHKIN,FAZZINI,FIDECARO,LIPMAN +      (CERN)
MERRISON  62 ADVP 11 1         A W MERRISON                     (LIVERPOOL)
DEPOMMIE  63 PL 7 285          P DEPOMMIER,HEINTZE,RUBBIA,SOERGEL    (CERN)
BARTLETT  64 PR 1368 1452      BARTLETT,DEVONS,MEYER,ROSEN       (COLUMBIA)
DI CAPUA  64 PR 1338 1333      DI CAPUA,GARLAND,PONDROM,STRELZOFF   (COLUM)

BACASTOW  65 PR 139 8407       +GHESQUIERE,WIEGAND,LARSEN         (LRL+SLAC)
BERTRAM   65 PR 139 B 617      BERTRAM,MEYER,CARRIGAN+     (MICH+CARNEGIE)
DUNAITSE  65 JETP 20 58        DUNAITSEV,PETRUKHIN,PROKOSHKIN +     (DUBNA)
ECKHAUSE  65 PL 19 348         ECKHAUSE,HARRIS,SHULER+  (WILLIAM AND MARY)
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.


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BARDON   66 PRL 16 775          BARDON,DORE,DORFAN,KRIEGER +      (COLUMBIA)
DUNAITSE 66 PL 23 283           +KUTYIN,PROKOSHKIN,RASUVAEV,SIMONOV (DUBNA)
KINSEY   66 PR 144   1132       KINSEY,LOBKCWICZ,NORDBERG  (ROCHESTER UNIV)
LOBKOWIC 66 PRL  17  548        LOBKOWICZ,MELISSINOS,NAGASHIMA+  (ROCH+BNL)

AYRES    67 PL 24B  483         D S AYRES,CALDWELL,GREENBERG,KURZ+     (LRL)
 ALSO    67 PR  157  1288       AYRES,CALDWELL,GREENBERG,KENNEY,KURZ+ (LRL)
NORDBERG 67 PL 24B  594         NORDBERG,LOBKOWICZ,BURMAN  (ROCHESTER UNIV)
SHAFER   67 PR 163 1451         ROBERT E. SHAFER                       (LRL)
  SEE ALSO  PRL 14 923          SHAFER,CROWE,JENKINS                   (LRL)

DEPOMMIE 68 NUC PHYS B4 189     DEPOMMIER,DUCLOS,HEINTZE,KLEINKNECHT+(CERN)
PETRUKHI 68 JINR-P1-3862        PETRUKHIN,RYKALIN,KHAZINS,CISEK     (DUBNA)
AYRES    69  UCRL-18369         DAVID S AYRES (THESIS)                (LRL)
 ALSO    68 PRL 21 261          AYRES,CORMACK,GREENBERG,KENNEY+  (LRL,UCSB)

                    PAPERS NCT REFERRED TO IN DATA CARDS

SHAPIRO  62 PR 125 1022         G SHAPIRO,L M LEDERMAN            (COLUMBIA)
CZIRR    63 PR 130  341         JOHN B CZIRR                           (LRL)

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                9  NEUTRAL PION  (135,JPG=0--)  I=1

                9  PI MASS DIFFERENCE (PI+-)-(PIO)(MEV)

D          (5.37)   (1.0)          PANOFSKY  51 CNTR  -
D           4.50     0.31          CHINOWSKY 54 CNTR  -
D           4.62     0.05          HADDOCK   59 CNTR  -
D           4.60     0.04          HILLMAN   59 CNTR
D           4.55     0.07          CASSELS   59 CNTR
D           4.6056   0.0055        CZIRR     63 CNTR
D           4.59     0.03          PETRUKHIN 63 CNTR  -
D           4.6034   0.0052        VASILEVSK 66 CNTR  -                9/66
D         . . . . . . . . .
D   AVG     4.6041   0.0037  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                9  PIO  LIFETIME (UNITS 10**-16)

T   N   76  (1.9)    (0.5)     (0.5)  GLASSER   61 EMUL
T   N   45  (2.3)    (1.1)     (1.0)  TIETGE    62 EMUL
T   N   88  (2.8)    (0.9)     (0.9)  KOLLER    63 EMUL    SEE STAMER 66
T            1.05     0.18      0.18  VON DARDE 63 CNTR
T   N   75  (1.7)    (0.5)            SHWE      64 EMUL
T            0.730    0.105           BELLETTIN 65 CNTR                6/66
T   N   67  (1.6)    (0.6)     (0.5)  EVANS     65 EMUL                6/66
T   N  OLD EMULSION MEASUREMENTS NOT USED BECAUSE OF POSSIBLE SYSTEMATIC
T   N        SHIFT TO LARGER LIFETIME VALUES
T  K  232   1.0      0.5              STAMER    66 EMUL                8/67
T  K    INCLUDES EVENTS OF KOLLER 63                                   8/67
T           (0.6)    (0.2)    (0.08) BRAUNSCHW 68 CNTR    PRIMAKOFF EFF. 9/68
T         . . . . . . . . .
T   AVG      0.89     0.18     0.14 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                     (SEE IDEOGRAM BELOW )
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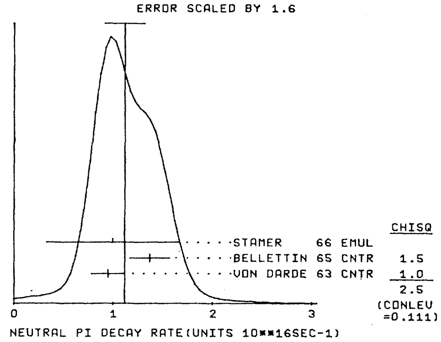
WEIGHTED AVERAGE = 1.12 ± 0.20
ERROR SCALED BY 1.6



NEUTRAL PI DECAY RATE(UNITS 10**16SEC-1)

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                9  NEUTRAL PION PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      PIO INTO 2GAMMA                                 0+   0
P2      PIO INTO E+ E- GAMMA                           .5+  .5+   0
P3      PIO INTO 4ELECTRONS                            .5+  .5+  .5+  .5
P4      PIO INTO 3 GAMMA                                0+   0+   0

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                9  NEUTRAL PION BRANCHING RATIOS

R1      PIO INTO (GAMMA E+ E-)/(2GAMMA)                  (P2)/(P1)
R1          (0.01196)THEORETICAL CALC.JOSEPH    60          QUANTUM ELECT.    9/66
R1      27    0.0117    0.0015          BUDAGCV   60 HBC
R1    3071   0.01166  0.00047           SAMIOS    61 HBC    PI-P TO PIO N
R1  S       SAMIOS VALUE USES PANOFSKY RATIO = 1.62
R1          . . . . . . . . .
R1  AVG       0.0117    0.0004  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2        PIO INTO (3 GAMMA)/(2 GAMMA) (UNITS 10**-6)    (P4)/(P1)
R2        0   (5.0)OR LESS              DUCLOS    65 CNTR   CL=90 PERCENT      6/66
R2            (5.0)  OR LESS            KUTIN     65 CNTR   90 PERCNT  C.L.    3/68

R3        PIO INTO (E+E+E-E-)/(2 GAMMA) (UNITS 10**-5)   (P3)/(P1)
R3            (3.47)  THEORETICAL CAL. KROLL    55          QUANTUM ELECT.     9/66
R3     146     3.18      0.30           SAMIOS    62 HBC    SEE NOTE N BELOW   6/66
R3  N       ABOVE VALUE USES PANOFSKY RATIO=1.62

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                                REFERENCES
                                9 NEUTRAL PION (135,JPG=0--)I=1

PANOFSKY 51 PR    81  565       W K H PANOFSKY,R L AAMODT,J HADLEY     (LRL)
CHINOWSK 54 PR    93  586       W CHINOWSKY,J STEINBERGER         (COLUMBIA)
KROLL    55 PR 98 1355          N KROLL ,W WADA              (COLUMBIA+NRLW)
CASSELS  59 PPS  74    92       CASSELS,JONES,MURPHY,O.NEILL     (LIVERPOOL)
HADDOCK  59 PRL    3  478       HADDOCK,ABASHIAN,CROWE,CZIRR           (LRL)
HILLMAN  59 NC    14  887       HILLMAN,MIDDELKOOP,YAMAGATA,ZAVATTINI(CERN)

BUDAGOV  60 JETP 11  755        BUDAGOV,VIKTOR,DZHELEPOV,ERMOLOV +    (JINR)
JOSEPH   60 NC 16 997           D W JOSEPH                             (EFI)
GLASSER  61 PR   123 1014       R G GLASSER,N SEEMAN,B STILLER         (NRL)
SAMIOS   61 PR   121  275       N P SAMIOS                    (COLUMBIA+BNL)
SAMIOS   62 PR 126 1844         SAMIOS,PLANO,PRODELL +        (COLUMBIA+BNL)
TIETGE   62 PR   127 1324       J TIETGE,W PUESCHEL       (MAX PLANCK INST)

CZIRR    63 PR   130  341       JOHN B CZIRR                           (LRL)
KOLLER   63 NC    27 1405       E L KOLLER,S TAYLOR,T HUETTER     (STEVENS)
KCLLER   63    SEE ALSO STAMER 66
PETRUKHI 63 SIENA CONF 208      V I PETRUKHIN,YU D PROKCSHKIN         (JINR)
VON DARD 63 PL     4   51       VON DARDEL,DEKKERS,MERMOD,VAN PUTTEN+(CERN)

SHWE     64 PR   136B 1839      H SHWE,F M SMITH,W H BARKAS            (LRL)
BELLETTI 65 NC 40 A 1139      . BELLETTINI,BEMPORAD,BRACCINI+(PISA+FIRENZE)
DUCLOS   65 PL 19 253           DUCLOS,FREYTAG,HEINTZE +  (CERN+HEIDELBERG)
EVANS    65 PR 139 B 982        D A EVANS                           (OXFORD)
KUTIN    65 JETP LETT 2 243     KUTIN,PETRUKHIN,PROKOSHKIN            (JINR)

STAMER   66 PR 151  1108        STAMER,TAYLOR,KOLLER,HUETTER+     (STEVENS)
VASILEVS 66 PL  23  281         VASILEVSKY,VISHNYAKOV,DUNAITSEV +   (DUBNA)

BRAUNSCH 68  VIENNA ABS.  297 BRAUNSCHWEIG,HUSMANN,LUBELSMEYER+    (BONN)

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$K^\pm$

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              10  CHARGED K  (494,JP=0-)  I=1/2

              10  CHARGED K  MASS (MEV)

M          493.9     0.2           COHEN     57 RVUE +
M          493.7     0.3           BARKAS    63 EMUL  -
M          493.78    0.17          GREINER   65 EMUL +   VIA TAU DECAY    7/66
M        . . . . . . . . .
M   AVG    493.81    0.12    AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.0)
M   FIT    493.82    0.11     VALUE FROM CONSTRAINED FIT                  6/68
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              10  CHAR.K  LIFETIME (UNITS 10**-8)

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                   CHARGED K CONSTRAINED FIT
            OVERALL FIT OF LIFETIME, WIDTHS AND BRANCHING
            RATIOS USES 48 DATA POINTS TO DETERMINE SEVEN
            QUANTITIES.  OVERALL FIT HAS  CHISQ=74.  MAIN
            CONTRIBUTION (12.7) COMES FROM R19 OF EICHTEN
            68 (WE SEE NO REASON TO REJECT THIS EXPERIMENT
            AT THIS TIME)

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T        CHAR. K LIFETIME
T            0.95     0.36     0.25  ILOFF     56 EMUL
T      52    1.60     0.3      0.3   EISENBERG 58 EMUL
T            1.21     0.06     0.06  BURROWES  59 CNTR
T      33    1.38     0.24     0.24  FREDEN    60 EMUL
T.           1.25     0.22     0.17  BARKAS    61 EMUL
T      51    1.27     0.36     0.23  BHOWMIK   61 EMUL
T     293    1.31     0.08     0.08  NORDIN    61 HBC   -
T           (1.24)   (0.07)          NORDIN    61 RVUE  -
T            1.231    0.011    0.011 BOYARSKI  62 CNTR +
T            1.2443   0.0038         FITCH     65 CNTR +                 6/66
T            1.2265   0.0036         LOBKOWICZ 66 CNTR +                 9/66
T            1.221    0.011          FORD      67 CNTR +-                8/67
T   G       (1.244)  (0.005)         GIACOMELL 67 CNTR +                 8/67
T   G     GIACOMELLI 67 VALUE JUST A CHECK ON APPARATUS
T          . . . . . . . . .
T   AVG      1.2343   0.0052   0.0052  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
T   FIT      1.2349   0.0043   VALUE FROM CONSTRAINED FIT
                      (SEE IDEOGRAM BELOW )
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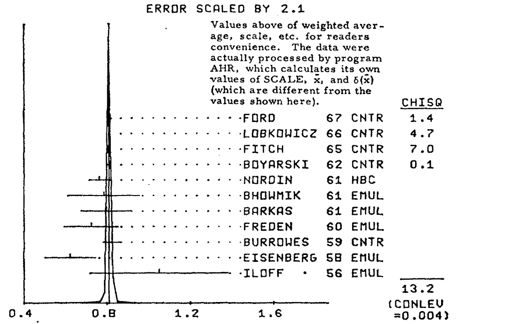
WEIGHTED AVERAGE = 0.8102 ± 0.0034
ERROR SCALED BY 2.1



CHARGED K DECAY RATE (UNITS 10**8 SEC-1)

Data in parentheses have not been included in our averages.

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                 10 LIFETIME DIFFERENCE,(+)-(-)/AVGE. (PERCENT)

DT  N    THIS QUANTITY IS A MEASURE OF CPT INVARIANCE IN W.I.

DT            0.049    0.097         LOBKOWICZ 66 CNTR     SEE NOTE L      9/66
DT  L    ABOVE IS THE MOST CONSERVATIVE VALUE QUOTED BY AUTHORS            9/66
DT            0.47     0.30          FORD      67 CNTR                     8/67
DT          • • • • • • • • •
DT  AVG       0.09     0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

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                  10  DECAY RATES DIFF.,(+)-(-)/AV.  (PERCENT)

D1      DIFFERENCE IN K MU2 RATES ((W1+)-(W1-))/W1
D1           -0.54     0.41          FORD      67 CNTR                     8/67

D2      DIFFERENCE IN TAU RATES   ((W2+)-(W2-))/W2
D2           -0.04     0.21          FORD      67 CNTR                     8/67
D2           -0.50     0.90          FLETCHER  67 OSPK                     8/67
D2          • • • • • • • • •
D2  AVG      -0.06     0.20    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)


D3      DIFFERENCE IN TAU PRIME RATES ((W4+)-(W4-))/AVERAGE
D3     1802  -0.0055   0.0090        HERZO     69 OSPK                    11/69*
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                 10  CHARGED K PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      CHAR. K INTO MU (NEU)               K MU2         105+   0
P2      CHAR. K INTO PI PIO                 K PI2         139+ 134
P3      CHAR. K INTO PI PI+ PI-             TAU           139+ 139+ 139
P4      CHAR. K INTO PI 2PIO                TAU PRIME     139+ 134+ 134
P5      CHAR. K INTO MU PIO NEU             K MU3         105+ 134+   0
P6      CHAR. K INTO E PIO NEU              K E3           .5+ 134+   0
P7      POSIT.K INTO PI+ PI- E+NEU          K E+ 4        139+ 139+  .5+   0
P8      POSIT.K INTO PI+ PI+ E-NEU          K E- 4        139+ 139+  .5+   0
P9       POSIT.K INTO PI+ PI- MU+ NEU       K+MU+ 4       139+ 139+ 105+   0
P10      POSIT.K INTO PI+ PI+ MU- NEU       K+MU- 4       139+ 139+ 105+   0
P11      CHAR. K INTO E NEU                 K E 2          .5+   0
P12      CHAR. K INTO MU NEU GAMMA          K MU RAD      105+   0+   0
P13      CHAR. K INTO PI PIO GAMMA          K PI RAD      139+ 134+   0
P14      CHAR. K INTO PI PI+ PI- GAMMA      TAU RAD       139+ 139+ 139+   0
P15      CHAR. K INTO PI E+ E-              PI E E        139+  .5+  .5
P16      CHAR. K INTO PI MU+ MU-            PI MU MU      139+ 105+ 105
P17      CHAR. K INTO PI GAMMA GAMMA        PI GAM GAM    139+   0+   0
P18      CHAR. K INTO PI E NEUTRINO GAMMA   PI E NEU GAM  139+  .5+   0+   0
P19      NEG.  K INTO PI+ E- E-             PI+E-E-       139+  .5+  .5
P20     CHAR. K INTO PI NEU NEU             PI NEU NEU    139+   0+   0

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                  10  CHARGED K DECAY RATES

W1      CHAR. K INTO MU NEU (K MU)       (UN. 10**6 SEC-1) (P1)
W1            51.2      0.8          FORD        67 CNTR +-                8/67
W1          • • • • • • • • •
W1  FIT       51.64     0.30    VALUE FROM CONSTRAINED FIT

W2      CHARG. K INTO PI PI+ PI- (TAU) (UN. 10**6 SEC-1) (P3)
W2            4.496     0.030        FORD        67 CNTR +-                8/67
W2          • • • • • • • • •
W2  FIT       4.513     0.029   VALUE FROM CONSTRAINED FIT

W3      CHAR. K INTO (TAU) - (TAU PRIME)  (UNITS 10**6 SEC-1)  (P3-P4)
W3      USED FOR DELTA I=1/2 TEST
W3          • • • • • • • • •
W3  FIT       3.135     0.044   VALUE FROM CONSTRAINED FIT

W4      CHAR. K INTO (MU PIO NEU) + (E PIO NEU)  (UNITS 10**6 SEC-1) (P5+P6)
W4      USED FOR DELTA I=1/2 TEST
W4          • • • • • • • • •
W4  FIT       6.50      0.12    VALUE FROM CONSTRAINED FIT

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                10  CHARGED K BRANCHING RATIOS

R   O      OLD DATA EXCLUDED

R1      CHAR. K INTO MU NEU (MU2)       (UNITS 10**-2)      (P1)/TOTAL
R1  O        (58.5)    (3.0)         BIRGE      56 EMUL +
R1  O        (56.9)    (2.6)         ALEXANDER 57 EMUL +
R1          • • • • • • • • •
R1  FIT       63.77     0.29    VALUE FROM CONSTRAINED FIT

R2      CHAR. K INTO PI PIO (PI2)       (UNITS 10**-2)      (P2)/TOTAL
R2  O        (27.7)    (2.7)         BIRGE      56 EMUL +
R2  O        (23.2)    (2.2)         ALEXANDER 57 EMUL +
R2           (21.0)    (0.6)         CALLAHAN   65 HLBC    SEE R17
R2           (21.6)    (0.6)         TRILLING   65 RVUE                    6/66
R2          • • • • • • • • •
R2  FIT       20.93     0.29    VALUE FROM CONSTRAINED FIT

R3      CHAR. K INTO PI PI+ PI-(TAU)  (UNITS 10**-2)      (P3)/TOTAL
R3  O         (5.6)    (0.4)         BIRGE      56 EMUL +
R3  O         (6.8)    (0.4)         ALEXANDER 57 EMUL +
R3  O         (5.2)    (0.3)         TAYLOR     59 EMUL +
R3             5.7      0.3          ROE        61 HLBC +                  9/66
R3     2332    5.54     0.12         CALLAHAN   64 HLBC +
R3      540    5.1      0.2          SHAKLEE    64 HLBC +                  9/66
R3             5.71     0.15         DE MARCO   65 HBC                     6/66
R3       44    6.0      0.4          YOUNG      65 EMUL +                  6/66
R3          • • • • • • • • •
R3  AVG        5.55     0.11   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R3  FIT        5.574    0.039   VALUE FROM CONSTRAINED FIT
                        (SEE IDEOGRAM BELOW )

R4      CHAR. K INTO PI 2PIO (TAU PRIME)(UNITS 10**-2)    (P4)/TOTAL
R4  O         (2.1)    (0.5)         BIRGE      56 EMUL +
R4  O         (2.2)    (0.4)         ALEXANDER 57 EMUL +
R4  O         (1.5)    (0.2)         TAYLOR     59 EMUL +
R4             1.7      0.2          ROE        61 HLBC +                 11/67
R4      108    1.8      0.2          SHAKLEE    64 HLBC +                 11/67
R4          • • • • • • • • •
R4  AVG        1.75     0.14   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  FIT        1.702    0.048   VALUE FROM CONSTRAINED FIT

R5      CHAR. K INTO MU PIO NEU (MU3) (UNITS 10**-2)      (P5)/TOTAL
R5  O         (2.8)    (1.0)         BIRGE      56 EMUL +
R5  O         (5.9)    (1.3)         ALEXANDER 57 EMUL +
R5  O         (2.8)    (0.4)         TAYLOR     59 EMUL +
R5          • • • • • • • • •
R5  FIT        3.18     0.11    VALUE FROM CONSTRAINED FIT
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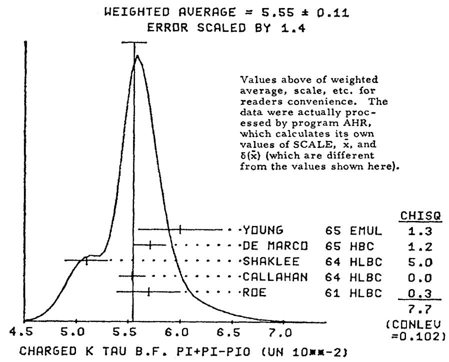


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R6      CHAR. K INTO E PIO NEU (E3)    (UNITS 10**-2)      (P6)/TOTAL
R6  O        (3.2)     (1.3)         BIRGE      56 EMUL +
R6  O        (5.1)     (1.3)         ALEXANDER 57 EMUL +
R6            5.0       0.5          ROE        61 HLBC +                 11/67
R6     429    4.7       0.3          SHAKLEE    64 HLBC +                 11/67
R6          • • • • • • • • •
R6  AVG       4.78      0.26   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  FIT       4.847     0.072   VALUE FROM CONSTRAINED FIT

R7      POSIT.K INTO PI+ PI- E+ NEU    (UNITS 10**-5)      (P7)/TOTAL

R8      POSIT.K INTO PI+ PI+ E- NEU    (UNITS 10**-7)      (P8)/TOTAL
R8          (20.)     OR LESS        BIRGE      65 FBC  +  95 PER CT CONF   8/66
R8       0  (6.9)     OR LESS        ELY        69 HLBC +  95 PER CT CONF  10/69*

R9       POSIT.K INTO PI+ PI- MU+ NEU (UNITS 10**-5)      (P9)/TOTAL
R9       1    0.77      0.54     0.50  CLINE    65 FBC  +                   8/66

R10      POSIT.K INTO PI+ PI+ MU- NEU (UNITS 10**-6)      (P10)/TOTAL
R10      0   (3.0)OR LESS            BIRGE      65 FBC  +  95 PER CT CONF   8/66

R11      CHAR. K INTO E NEU             (UNITS 10**-5)      (P11)/TOTAL
R11        (160.0)  OR LESS          BORREANI   64 HBC  +  CONLEV=0.95     11/67
R11      4    2.1       1.8      1.3  BOWEN     67 OSPK +                   8/67
R11      BOWEN RESULT SHOULD BE CORRECTED TO 1.9(+1.7,-1.2) BECAUSE OF
R11      K+ TO E+ NEU GAMMA DECAYS BEFORE COMPARING WITH BOTTERILL 67 R28

R12      CHAR. K INTO MU NEU GAMMA      (UNITS 10**-5)      (P12)/TOTAL

R13      CHAR. K INTO PI PIO GAMMA      (UNITS 10**-4)      (P13)/TOTAL
R13      18   (2.2)     (0.7)        CLINE      64 FBC  +  PI+ KE 55-80 MEV  8/66
R13 E     0   (1.9)    OR LESS       EMMERSON   69 OSPK    PI+  55-80 MEV  10/69*
R13 E       90 PER CENT CONFIDENCE                                         10/69*

R14      CHAR. K INTO PI PI+ PI- GAMMA(UNITS 10**-4)      (P14)/TOTAL
R14           1.0       0.4          STAMER     65 EMUL +                   8/66

R15      CHAR. K INTO PI E+ E-          (UNITS 10**-6)      (P15)/TOTAL
R15       1   (1.1)   OR LESS        CAMERINI   64 FBC  +                   8/66
R15           (0.4)   OR LESS        CLINE      67 FBC  +                  11/67
R15           (4.4)   OR LESS        BISI       67 DBC  +  90 PER CT CONF  11/67

R16      CHAR. K INTO PI MU+ MU-        (UNITS 10**-6)      (P16)/TOTAL
R16           (3.0)   OR LESS        CAMERINI   65 FBC  +  90 PER CT CONF   8/66
R16           (2.4)   OR LESS        BISI       67 DBC  +  90 PER CT CONF  11/67

R17      CHAR. K INTO (PI PIO)/TAU                         (P2)/(P3)
R17     134    3.24     0.34         YOUNG      65 EMUL +                   8/66
R17    1045    3.96     0.15         CALLAHAN   66 FBC  +                   9/66
R17          • • • • • • • • •
R17 AVG        3.84     0.27   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R17 FIT        3.755    0.061   VALUE FROM CONSTRAINED FIT

R18      CHAR. K INTO (PI 2PIO)/TAU                        (P4)/(P3)
R18    2027    0.303    0.009        BISI       65 H+HL +                   8/66
R18      17    0.393    0.099        YOUNG      65 EMUL +                   8/66
R18          • • • • • • • • •
R18 AVG        0.3037   0.0090 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 FIT        0.3054   0.0085  VALUE FROM CONSTRAINED FIT

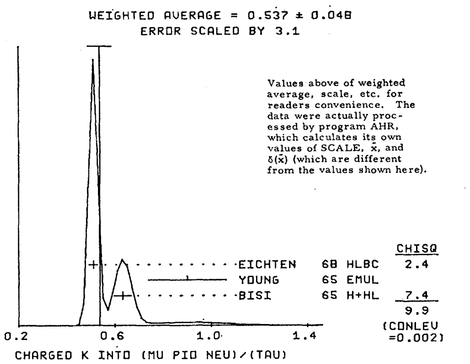
R19      CHAR. K INTO (MU PIO NEU)/TAU                     (P5)/(P3)
R19    2175    0.632    0.035        BISI       65 H+HL +                   8/66
R19      38    0.90     0.16         YOUNG      65 EMUL +                   8/66
R19    1505    0.510    0.017        EICHTEN    68 HLBC +                  11/68
R19          • • • • • • • • •
R19 AVG        0.537    0.048  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.1)
R19 FIT        0.571    0.021   VALUE FROM CONSTRAINED FIT
                        (SEE IDEOGRAM BELOW )

R20      CHAR. K INTO (E PIO NEU)/TAU                      (P6)/(P3)
R20     230    0.90     0.06         BORREANI   64 HBC  +                   8/66
R20      37    0.90     0.16         YOUNG      65 EMUL +                   8/66
R20     854    0.94     0.09         BELLOTT2   67 HLBC                    11/67
R20    4385    0.846    0.021        EICHTEN    68 HLBC +                  11/68
R20          • • • • • • • • •
R20 AVG        0.857    0.019  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R20 FIT        0.870    0.013   VALUE FROM CONSTRAINED FIT

R21      POSIT.K INTO (PI+ PI- E+ NEU)/TAU(UNITS 10**-4)(P7)/(P3)
R21      69    6.7      1.5          BIRGE      65 FBC  +                   8/66
R21     269    5.83     0.63         ELY        69 HLBC                    11/68
R21          • • • • • • • • •
R21 AVG        5.96     0.58   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R22      POSIT.K INTO (PI+ PI- MU+ NEU)/TAU(UNITS 10**-4)(P9)/(P3)
R22       1   (2.5)   APPROX         GREINER    64 EMUL +                   8/66
R22       7    2.57     1.55         BISI       67 DBC  +                  11/67
```

Data in parentheses have not been included in our averages.

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R23     CHAR. K INTO (E PIO NEU)/(MU2+PI2)(UNITS 10**-2)(P6)/(P1+P2)
R23   1679    5.89      0.21           CESTER    66 OSPK +                8/67
R23   5110    6.16      0.22           ESCHSTRUT 68 OSPK +                3/68
R23          . . . . . . . . . .
R23 AVG       6.02      0.15    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R23 FIT       5.723     0.092    VALUE FROM CONSTRAINED FIT

R24     CHAR. K INTO (PI PIO)/(MU NEU)                      (P2)/(P1)
R24           0.3253    0.0065         AUERBACH  67 OSPK +                8/67
R24   1600    0.305     0.018          ZELLER    69 ASPK +               10/69*
R24          . . . . . . . . . .
R24 AVG       0.3230    0.0065  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R24 FIT       0.3282    0.0059   VALUE FROM CONSTRAINED FIT

R25     CHAR. K INTO (E PIO NEU)/(MU NEU)                   (P6)/(P1)
R25    472'   0.0797    0.0054         AUERBACH  67 OSPK +                8/67
R25    THE VALUE .0785+-.0025 GIVEN IN THE ABOVE REF IS AN AVERAGE OF
R25    AUERBACH 67 R25 AND CESTER 66 R23.
R25    960     .0775     .0033         BOTTERI1  68 ASPK +                5/68
R25    561    0.069     0.006          GARLAND   68 OSPK +                4/68
R25    350    0.069      0.006         ZELLER    69 ASPK +               10/69*
R25          . . . . . . . . . .
R25 AVG       0.0753    0.0025  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R25 FIT       0.0760    0.0012   VALUE FROM CONSTRAINED FIT

R26     CHAR. K INTO (MU PIO NEU)/(MU NEU)                  (P5)/(P1)
R26    310    0.0602    0.0046         AUERBACH  67 OSPK +                8/67
R26    424    0.055     0.004          GARLAND   68 OSPK +                4/68
R26    240    0.054     0.009          ZELLER    69 ASPK +               10/69*
R26          . . . . . . . . . .
R26 AVG       0.0569    0.0029  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R26 FIT       0.0499    0.0019   VALUE FROM CONSTRAINED FIT

R27     CHAR. K INTO (MU NEU)/(TAU)                         (P1)/(P3)
R27 R  427  (10.38)    (0.82)          YOUNG     65 EMUL +                9/66
R27 R DELETED FROM OVERALL FIT BECAUSE YOUNG 65 CONSTRAINS HIS RESULTS
R27 R TO ADD UP TO 1.  ONLY YOUNG MEASURED MU2 DIRECTLY.
R27          . . . . . . . . . .
R27 FIT      11.44      0.10     VALUE FROM CONSTRAINED FIT

R28    CHAR. K INTO (E NEU)/(MU NEU) (UNITS 10**-5)    (P11)/(P1)
R28     10    1.9       0.7       0.5  BOTTERILL 67 ASPK +               11/67
R28      8    1.8       0.8       0.6  MACEK     69 ASPK +                4/69*
R28          . . . . . . . . . .
R28 AVG       1.86      0.46    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R29    CHAR. K INTO (MU PIO NEU)/(E PIO NEU)               (P5)/(P6)
R29  C1509    0.703     0.056          CALLAHA1  66 HLBC                  6/68
R29 A 1398   (0.604)   (0.022)         EICHTEN   68 HLBC                 10/68
R29   5601    0.667     0.017          BOTTERI2  68 ASPK +                6/68
R29                  COMMENTS
R29 A     ONLY INDIVIDUAL RATIOS INCLUDED IN FIT--SEE R19 AND R20--      11/68
R29  C FROM THIS EXPERIMENT WE USE ONLY THE MU3/E3 RATIO AND DO NOT
R29  C INCLUDE IN THE FIT THE RATIOS MU3/TAU AND E3/TAU, SINCE THEY
R29  C SHOW LARGE DISAGREEMENTS WITH THE REST OF THE DATA.
R29          . . . . . . . . . .
R29 AVG       0.670     0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R29 FIT       0.656     0.023    VALUE FROM CONSTRAINED FIT

R30     CHAR. K INTO PI GAMMA GAMMA/TOTAL(UNITS 10**-4)(P17)/TOTAL
R30          (1.1)  OR LESS            CHEN      68 OSPK +                5/68

R31    CHAR. K INTO PI E NEU GAMMA/PI E NEU                (P18)/(P6)
R31           0.012     0.008          BELLOTTI  67 HLBC +               11/67

R32     CHAR. K INTO (PI2 + MU3)/(TOTAL)                   (P2+P5)/TOTAL  11/67
R32    WE COMBINE THESE TWO MODES FOR EXPTS MEASURING THEM IN XENON BC
R32    BECAUSE OF DIFFICULTIES OF SEPARATING THEM THERE
R32          23.4       1.1            ROE       61 HLBC +               11/67
R32    886   25.4       0.9            SHAKLEE   64 HLBC +               11/67
R32          . . . . . . . . . .
R32 AVG      24.60      0.98    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R32 FIT      24.11      0.29     VALUE FROM CONSTRAINED FIT

R33    K- INTO PI+ E- E-/TOTAL (UNITS 10**-5)              (P19)/TOTAL
R33      TEST OF LEPTON NUMBER CONSERVATION
R33          (1.5)  OR LESS            CHANG     68 HBC   - CL=           3/68

R34    CHAR. K INTO PI NEU NEU/ TOTAL  (UNITS 10**-4)   (P20)/TOTAL
R34          (1.0)  OR LESS            CAMERINI  68     +  TEST NEUTR.CURR. 11/68

R35    CHAR. K INTO (TAU)/(TAU PRIME)                 (P3/P4)
R35    USED FOR DELTA I=1/2 TEST
R35          . . . . . . . . . .
R35 FIT       3.275     0.091    VALUE FROM CONSTRAINED FIT
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.638+-.003					
P 2	-.831	.209+-.003				
P 3	-.167	-.084	.056+-.000			
P 4	-.149	-.062	.204	.017+-.000		
P 5	-.267	-.194	.094	.008	.032+-.001	
P 6	-.246	-.208	.185	.021	.498	.048+-.001

Fitted Partial Decay Rates

Diagonal elements are $W_i \pm \delta W_i$; $W_i = \Gamma_{total} P_i$; $\delta W_i = \sqrt{\langle \delta W_i \delta W_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta W_i \delta W_j \rangle / (\delta W_i \cdot \delta W_j)$.

	W 1	W 2	W 3	W 4	W 5	W 6
W 1	.516+-.003					
W 2	-.421	.169+-.003				
W 3	-.086	-.027	.045+-.000			
W 4	-.088	-.039	.191	.014+-.000		
W 5	-.163	-.160	.097	.009	.026+-.001	
W 6	-.088	-.140	.183	.022	.502	.039+-.001

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K^+ Form Factors

The definition of all the variables listed in this section can be found in the text.

The values of ξ as obtained in μ polarization measurements (ξ_B) are still in disagreement with the values obtained from branching ratios and spectra (ξ_A).

It now appears that λ_+ is different from zero for both K^+ and K_L^0 decays; therefore, in calculating ξ from branching ratios and spectra this energy dependence should be taken into account. The μ polarization measurements are less sensitive to the q^2 dependence. For example, using the relation for the $K_{\mu 3}/K_{e3}$ branching ratio given in the text, the contribution of the λ_+ term (taking $\lambda_+ = 0.03$) is $\Delta\xi = (-1.39\times 0.03)/0.127 = - 0.33$. For this reason we have not averaged the values of ξ_A which were obtained from branching ratios by assuming $\lambda_+ = \lambda_- = 0$. At the present time there is no evidence for an energy dependence of f_-, but the data are not inconsistent with a large λ_- (see CRONIN 68, who uses $\lambda = - 0.14$).

We have listed the values of $T = q^2/m_\pi^2$ whenever available, for possible future use.

Notice that the only published experiment (the X_2 collaboration) which determines ξ from all three methods (see HAIDT-2 69) shows no disagreement at all. The overall fit of the data of this experiment gives $\xi(5.0) = - 0.58\pm0.13$, for $\lambda_+ = + 0.029$ and $\lambda_- = -0.13$.

Data in parentheses have not been included in our averages.

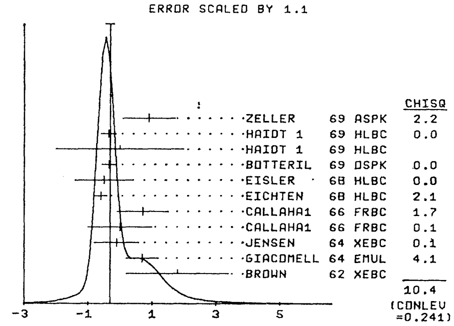
```
                 10  CHARGED K FORM FACTORS                              8/67

           F+ AND F- ARE FORM FACTORS FOR THE VECTOR MATRIX ELEMENT
           FS AND FT REFER TO THE SCALAR AND TENSOR TERM

XIA     XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3)  ---------------
XIA
XIA      UNLESS OTHERWISE NOTED, THE EXPERIMENTS BELOW EVALUATE
XIA      XI ASSUMING THAT IT IS INDEPENDENT OF MOMENTUM TRANSFER,
XIA      I.E. THEY SET LM+=LM-=0 AND REPORT THEIR RESULT AS XI AT T=0.
XIA      IN REALITY, HOWEVER, THEY HAVE MEASURED XI OVER SOME
XIA      REGION WHERE T IS NOT ZERO
XIA      THE AVERAGE MADE BELOW IGNORES THAT T DEPENDENCE.

XIA       76   +1.8      1.6               BROWN     62 XEBC +  MU+,PIO SPECTRA   8/67
XIA       87   +0.7      0.5               GIACOMELL 64 EMUL +  MU+ SPECTRUM      8/67
XIA            -0.1      0.7               JENSEN    64 XEBC +  MU+,PIO SPECTRN   8/67
XIA L        (-0.17)    (0.75)    (0.99)   SHAKLEE   64 XEBC +  KMU3/KE3          8/67
XIA L        (+0.6)     (0.5)              BISI 1    65 HBC  +  KMU3/KE3          8/67
XIA          BTWN +0.2 AND +1.4            CUTTS     65 OSPK +  MU+ SPECTRUM      8/67
XIA L 1509   (+0.4)     (0.4)              CALLAHA1  66 FRBC +  KMU3/KE3          8/67
XIA   2648    0.0        1.1       0.9     CALLAHA1  66 FRBC +  MU+ SPECTRUM      8/67
XIA    444   +0.72       0.80              CALLAHA1  66 F-BC +  P+0 SPEC,FIX MU   8/67
XIA L        (+0.75)    (0.50)             AUERBACH  67 OSPK +  KMU3/KE3          8/67
XIA  E1398   -0.60       0.20              EICHTEN   68 HLBC +  KMU3/KE3 T=4.    10/68
XIA B 5601   (-0.08)    (0.15)             BOTTERIL2 68 ASPK +  KM3/KE3,LM+=.023  6/68
XIA     78   -0.5        0.9               EISLER    68 HLBC +  PIO SPECT,LM+-=0  6/68
XIA L  976   (+1.0)     (0.6)              GARLAND   68 OSPK +  KMU3/KE3,LM+-=0   4/68
XIA  B       -0.35       .22               BOTTERIL  69 OSPK    KM3/KE3,LM+=.045 10/69*
XIA  H3240    0.         2.                HAIDT 1   69 HLBC  + DAL. PLOT  T=0   10/69*
XIA  H3240   -0.36       0.24              HAIDT 1   69 HLBC  + DAL. PLOT  T=6.8 10/69*
XIA           0.91       0.82              ZELLER    69 ASPK +  KM3/KE3 NOTE Z   10/69*
XIA  B  T=0        BOTTERIL 69 IS REEVALUATION OF BOTTERIL2 68 WITH DIFF.LM+ 10/69*
XIA E   T=4   ASSUMES LM+=0.023+-0.008        INSENSITIVE TO LM-
XIA  H     HAIDT 69 ASSUMES LM+=.029-VALUES AT T=0, T=6.8 ARE UNCORRELATED
XIA L    LM+ AND LM- ASSUMED TO BE ZERO - NOT AVERAGED
XIA Z   T=0    ZELLER 69 ASSUMES LM+=0.023, LM-=0
XIA          . . . . . . . . . .
XIA AVG      -0.31       0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
                        (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = -0.31 ± 0.13
ERROR SCALED BY 1.1



F-/F+ FOR CHGD K DECAY (FROM SPECTRA)

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XIB     XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)  ------------

XIB     MEAS OF XI USING POLARIZATION IS LESS SENSITIVE TO FORM FACTOR
XIB     VARIATIONS.

XIB    2100   +1.2      2.4      1.8    BORREANI  65 HLBC +  POLARIZATION      8/67
XIB     397   -1.4      1.8             CALLAHA1  66 F-BC +  TOTAL POLA-.      8/67
XIB    2950   -0.7      0.9      3.3    CALLAHA1  66 FRBC +  LONG. POLAR.      8/67
XIB   86000   -0.6      1.1             BETTELS   68 FRBC +  TOTAL POL. T=0   11/69*
XIB   86000   -1.0      0.3             BETTELS   68 FRBC +  TOTAL POL. T=4.9 11/69*
XIB    3133   -0.95     0.3             CUTTS     68 OSPK +  TOTAL POL. T=3    6/68
XIB B   BETTELS 68 VALUES AT T=0 AND T=4.9 ARE UNCORRELATED
XIB          . . . . . . . . . .
XIB AVG      -0.94      0.20  .  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

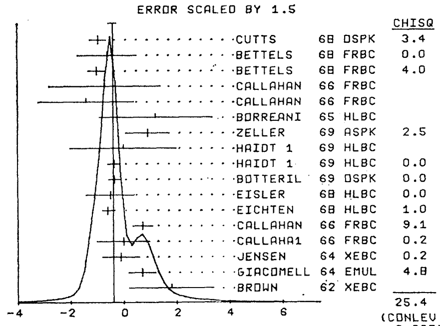
RXI        REAL PART OF XI   (COMBINED XIA AND XIB)
RXI      76   +1.8      1.6             BROWN     62 XEBC +
RXI      87   +0.7      0.5             GIACOMELL 64 EMUL +
RXI           -0.1      0.7             JENSEN    64 XEBC +
RXI    2648    0.0      1.1      0.9    CALLAHA1  66 FRBC +
RXI     444   +0.72     0.37            CALLAHAN  66 FRBC +
RXI    1398   -0.60     0.20            EICHTEN   68 HLBC +
RXI      78   -0.5      0.9             EISLER    68 HLBC +
RXI  B        -0.35      .22            BOTTERIL  69 OSPK
RXI  H3240    -0.36     0.24            HAIDT 1   69 HLBC  +
RXI  H3240     0.       2.              HAIDT 1   69 HLBC  +
RXI            0.91     0.82            ZELLER    69 ASPK +
RXI    2100   +1.2      2.4      1.8    BORREANI  65 HLBC +
RXI     397   -1.4      1.8             CALLAHAN  66 FRBC +
RXI    2950   -0.7      0.9      3.3    CALLAHAN  66 FRBC +
RXI   86000   -1.0      0.3             BETTELS   68 FRBC +
RXI   86000   -0.6      1.1             BETTELS   68 FRBC +
RXI    3133   -0.95     0.3             CUTTS     68 OSPK +
RXI          . . . . . . . . . .
RXI AVG      -0.40      0.15     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                       (SEE IDEOGRAM BELOW )

IXI        IMAGINARY PART OF XI (TEST OF T REVERSAL)  ------------------
IXI           0.1       0.4      0.3    BETTELS   68 HLBC    POLARIZATION     10/69*

FS      FS/F+  RATIO OF SCALAR TO F+ COUPLINGS  (ABS. VALUE)  ------------

FS            (.18) OR LESS             BELLOTT2  67 HLBC    90 PERC. CONFLEV 10/69*
FS            (.30) OR LESS             KALMUS    67 HLBC  + 95 PERC. CONFLEV 10/69*
FS            (0.23)  OR LESS           BOTTERIL1 68 ASPK     CL=90 PERCENT    8/66
```

WEIGHTED AVERAGE = -0.40 ± 0.15
ERROR SCALED BY 1.5



COMBINED F-/F+ USING BOTH XIA AND XIB

```
FT      FT/F+  RATIO OF TENSOR TO F+ COUPLINGS  (ABS. VALUE)  ------------

FT           (.58) OR LESS            BELLOTT2  67 HLBC    90 PERC. CONFLEV 10/69*
FT           (1.1)  OR LESS           KALMUS    67 HLBC  + 95 PERC. CONFLEV 10/69*
FT           (0.58)  OR LESS          BOTTERIL1 68 ASPK     CL=90 PERCENT    8/66

LM+     LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KE3 DECAY)  ---------
LM+     FOR RAD. CORR. TO THE DALITZ PLOT, SEE GINSBERG 67.

LM+     217   +0.038     .045             BROWN     62 XEBC +  PIO SPEC,NO R.C.
LM+     407   -0.010     .029             JENSEN    64 XEBC +  PIO SPEC,NO R.C.  8/67
LM+     230   -0.04      .05              BORREANI  64 HBC  +  E+ SPEC,NO R.C.   8/67
LM+ B   457   (+0.025)   (.018)           BELLOTTI  66 FBC  +  SEE NOTE B BELOW  8/67
LM+     854    0.045     0.017    0.018   BELLOTT2  67 FBC  +  SEE NOTE B BELOW 11/67
LM+ B      BELLOTT2 67 REPLACES BELLOTTI 66.USES DALITZ PLOT WITH RAD. COR. 11/67
LM+    1393   +0.016     .016             IMLAY     67 OSPK +  DLTZ PLT,NO R.C.  8/67
LM+     515   +0.028     .013     .014    KALMUS    67 FBC  +  E,PI SPEC,NO R.C. 8/67
LM+     960   (.08)      (.04)            BOTTERIL1 68 ASPK +  E SPEC USES R.C.  6/68
LM+      90   -0.02      0.08     0.12    EISLER    68 HLBC +  PIO SPEC,NO R.C.  6/68
LM+    1458    .045      .015             BOTTERIL  69 OSPK    PIO SPECTRUM RC  10/69*
LM+    1347   (0.053)    (0.026)  (0.021) HAIDT 1   69 HLBC    KMU3 DALITZ PLOT 11/69*
LM+ $      HAIDT 1 69 NOT AVERAGED BECAUSE INDIRECT MEASUREMENT.              11/69*
LM+          . . . . . . . . . .
LM+ AVG        0.0286    0.0074  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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                 10  CHARGED K  ENERGY DEPENDENCE OF DALITZ PLOT

        MATRIX ELEMENT SQUARED =  1 + G (S3-S0)/(MPI**2)

GT+  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  CHARGED K INTO PI PI+PI-
GT+    5428   -0.22      0.024            ZINCHENKO 67 HBC  +  ALSO OBC        10/69*
GT+    9994   -0.218     0.016            BUTLER    68 HBC  +                  10/69*
GT+   17898   -0.196     0.016            GRAUMAN   69 HLBC +  EMULS DATA ADDED 10/69*
GT+          . . . . . . . . . .
GT+ AVG       -0.2061    0.0089  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

GT-  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  CHARGED K INTO PI PI+PI-
GT-    1347   (-0.220)   (0.035)          FERRO-LUZ 61 HBC  -  NO RAD CORR     10/69*
GT-    5778   -0.190     0.023            MOSCOSO   68 HBC  -  ALSO OBC        10/69*
GT-   50919   -0.194     0.007            MAST      69 HBC  -                  10/69*
GT-          . . . . . . . . . .
GT- AVG       -0.1937    0.0067  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

GTP  LINEAR ENERGY DEPENDENCE (G) FOR TAU PRIME DECAY CHA.K INTO PI PIOPIO
GTP    1792    0.48      0.04             KALMUS    64 HLBC +                  10/69*
GTP    1874    0.586     0.098            BISI 1    65 HLBC +  ALSO HBC        10/69*
GTP    4048    0.516     0.020            DAVISON   69 HLBC +  ALSO EMUL       10/69*
GTP          . . . . . . . . . .
GTP AVG        0.511     0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                    REFERENCES
                    10 CHARGED K (494,JP=0-)I=1/2

BIRGE     56 NC  4    834     BIRGE,PERKINS,PETERSON,STORK,WHITEHEA (LRL)
ILOFF     56 PR 102   927     ILOFF,GOLDHABER,LANNUTTI,GILBERT +     (LRL)
ALEXANDE  57 NC  6    478     ALEXANDER,JOHNSTON,OCEALLAIGH (DUBLIN INST)
COHEN     57 FUND.CONS.PHYS.  E R COHEN,K M CROWE,J DUMOND     (AI+LRL+CIT)
EISENBER  58 NC  8    663     EISENBERG,KOCH,LOHRMANN,NIKOLIC +     (BERN)
BURROWES  59 PRL 2    117     BURROWES,CALDWELL,FRISCH,HILL +        (MIT)
TAYLOR    59 PR 114   359     S TAYLOR,HARRIS,OREAR,LEE,BAUMEL (COLUMBIA)

FREDEN    60 PR 118   564     S C FREDEN,F C GILBERT,R S WHITE       (LRL)
BARKAS    61 PR 124  1209     BARKAS,DYER,MASON,NORRIS,NICKOLS,SMIT (LRL)
BHOWMIK   61 NC  20   857     B BHOWMIK,P C JAIN,P C MATHUR  (DELHI UNIV)
FERRO-LU  61 NC  22  1087     FERRO-LUZZI,MILLER,MURRAY,ROSENFELD+  (LRL)
NORDIN    61 PR 123  2166     PAUL NORDIN JR                         (LRL)
ROE       61 PRL 7    346     ROE,SINCLAIR,BROWN,GLASER +       (MICH+LRL)
BOYARSKI  62 PR 128  2398     BOYARSKI,LOH,NIEMELA,RITSON            (MIT)
BROWN     62 PRL 8    450     BROWN,KADYK,TRILLING,ROE+         (LRL,MICH)

BARKAS    63 PRL 11    26     W H BARKAS,J N DYER,H H HECKMAN        (LRL)
BORREANI  64 PL  12   123     G BORREANI,G RINAUDO,A WERBROUCK     (TURIN)
CALLAHAN  64 PR  136 B1463    A CALLAHAN,R MARCH,R STARK       (WISCONSIN)
CAMERINI  64 PRL 13   318     CAMERINI,CLINE,FRY,POWELL    (WISCONSIN+LRL)
CLINE     64 PRL 13   101     D CLINE, W F FRY                 (WISCONSIN)
GIACOMEL  64 NC  34  1134     GIACOMELLI,MONTI,QUARENI+ (BOLOGNA,MUNICH)
GREINER   64 PRL 13   284     D GREINER, W OSBORNE, W BARKAS         (LRL)
JENSEN    64 PR  136 B1431    JENSEN,SHAKLEE,ROE,SINCLAIR       (MICHIGAN)
KALMUS    64 PRL 13    99     +KERNAN,PU,POWELL,DOWD            (LRL,WISC)
SHAKLEE   64 PR  136 B1423    SHAKLEE,JENSEN,ROE,SINCLAIR       (MICHIGAN)
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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BIRGE    65 PR 139 B 1600      BIRGE,ELY,GIDAL,CAMERINI,CLINE +  (LRL+WIS)
BISI     65 NC   35  768       BISI,BORREANI,CESTER,FERRARO +       (TURIN)
BISI 1   65 PR 139 B 1068      .BISI,MARZARI-CHIESA,RINAUDO   (TURINO,INFN)
BORREANI 65 PR 140 B1686       BORREANI,GIDAL,RINAUDO,CAFORIO+(BARI,TURIN)
CALLAHAN 65 PRL  15  129       A CALLAHAN,D CLINE               (WISCONSIN)
CAMERINI 65 NC   37 1795       CAMERINI,CLINE,GIDAL,KALMUS,KERNAN(WIS+LRL)
CLINE    65 PL   15  293       A CLINE,W F FRY                  (WISCONSIN)
CUTTS    65 PR 138 B969        CUTTS,ELIOFF,STIENING                  (LRL)
DE MARCO 65 PR 140 B 1430      DE MARCO,GROSSO,RINAUDO      (TURINO+CERN)
   ALSO  68 PR 169 1045        SAYER,BEALL,DEVLIN,SHEPHARD+(MD+PPA+PALMER)
FITCH    65 PR 140 B 1088      FITCH,QUARLES,WILKINS  (PRINCETON+MT HOLYK)
GREINER  65 ARNS  15  67       QUOTED BY BARKAS                       (LRL)
STAMER   65 PR  138 B 440      STAMER,HUETTER,KOLLER,TAYLOR,GRAUMAN (STEV)
TRILLING 65 UCRL 16473         GEORGE H TRILLING                      (LRL)
TRILLING 65   IS UPDATED FROM 1965 ARGONNE CONF, PAGE  5
YOUNG    65 UCRL 16362         POH-SHIEN YOUNG (THESIS,BERKELEY)      (LRL)
  ALSO   67 PR 156 1464        P-S YOUNG,W.Z.OSBORNE,W.H.BARKAS       (LRL)

BELLOTTI 66 PL  20  690        BELLOTTI,FIORINI,PULLIA+             (MILAN)
CALLAHA1 66 PR 150 1153        CALLAHAN,CAMERINI+(WISC,LRL,RIVERSIDE,BARI)
CALLAHAN 66 NC  44A 90         A C CALLAHAN                     (WISCONSIN)
CESTER   66 PL 21 343          CESTER,ESCHSTRUTH,ONEILL+  (PRINCETON-PENN)
CESTER   66    SEE ALSO FOOTNOTE 1 OF AUERBACH 67
LOBKOWIC 66 PRL  17  548       LOBKOWICZ,MELISSINOS,NAGASHIMA+  (ROCH+BNL)

AUERBACH 67 PR 155  1505       +DOBBS,MANN,MCFARLANE,WHITE+     (PENN,PRIN)
BELLOTT1 67 HEIDELBERG CONF    BELLOTTI,PULLIA                      (MILAN)
BELLOTT2 67 NC 52A  1287       BELLOTTI,FIORINI,PULLIA              (MILAN)
BISI     67 PL 25B  572        BISI,CESTER,CHIESA,VIGONE           (TORINO)
BOTTERIL 67 PRL  19  982       BOTTERILL,BROWN,CORBETT,CULLIGAN + (OXFORD)
BOTTERIL 67    SEE ALSO BOTTERILL 68
BOWEN    67 PR 154 1314        BOWEN,MANN,MCFARLANE,HUGHES+(PENN-PRINCETO)

CLINE    67 HEIDELBERG CONF    CLINE,HAGGERTY,SINGLETON,FRY+    (WISCONSIN)
FLETCHER 67 PRL  19  98        FLETCHER,BEIER,EDWRADS,+          (ILLINOIS)
FORD     67 PRL 18 1214        +LEMONICK,NAUENBERG,PIROUE       (PRINCETON)
GIACOMEL 67 BNL 11056          GIACOMELLI,KYCIA,LI,TEIGER             (BNL)
GINSBERG 67 PR 162  1570       EDWARD S GINSBERG          (U. MASS BOSTON)
IMLAY    67 PR 160  1203       IMLAY,FSCHSTRUTH,FRANKLIN+       (PRINCETON)
KALMUS   67 PR  159  1187      KALMUS,KERNAN                          (LRL)
ZINCHENK 67 RUTGERS(THESIS)    ZINCHENKO                          (RUTGERS)

BETTELS  68 NC 56A 1106        AACHEN-BARI-BERGEN-CERN-EP-NIJMEGEN-ORSAY+
BOTTERIL 68 PR 171 1402        BOTTERILL,BROWN,CORBETT,CULLIGAN+  (OXFORD)
BOTTERI1 68 PR 174 1661        BOTTERILL,BROWN,CLEGG,CORBETT,+    (OXFORD)
BOTTERI2 68 PRL 21 766         BOTTERILL,BROWN,CLEGG,CORBETT +    (OXFORD)
BUTLER   68 UCRL-18420         +BLAND,GOLDHABER,GOLDHABER,HIRATA+   (LRL).
CAMERINI 68  VIENNA ABS. 537   CAMERINI,CLINE,LJUNG                  (WISC)
CHANG    68 PRL 20  510        CHANG,YODH,EHRLICH,PLANO+(MARYLAND,RUTGERS)

CHEN     68 PRL 20 73          CHEN,CUTTS,KIJEWSKI,STIENING +    (LRL,MIT)
CUTTS    68 PRL 20 955         CUTTS,STIENING,WIEGAND,DEUTSCH    (LRL,MIT)
EICHTEN  68 PL 27B 586         AACHEN-BARI-CERN-EP-ORSAY-PADOVA-VALENCIA
EISLER   68 PR  169  1090      EISLER,FUNG,MARATECK,MEYER,PLANO (RUTGERS)
ESCHSTRU 68 PR  165  1487      ESCHSTRUTH,FRANKLIN,HUGHES+(PRINCETON,PENN)
GARLAND  68 PR  167  1225      +TSIPIS,DEVONS,ROSEN+  (COLUMBIA,RUTG,WISC)
MOSCOSO  68  THESIS            M L MOSCOSO               (UNIV PARIS ORSAY)

BOTTERIL 69  PREPRINT          +BROWN,CLEGG,CORBETT,CULLIGAN+        (OXF)
DAVISON  69 PR  180 1333       +BACASTOW,BARKAS,EVANS,FUNG,PORTER+  (RIVS)
ELY      69 PR  180 1319       ELY,GIDAL,HAGOPIAN,KALMUS+    (UCL,WIS,LRL)
EMMERSON 69 PRL 23 393         EMMERSON,QUIRK                      (OXFORD)
GRAUMAN  69 PRL 23  737        +TAYLOR,KOLLER,PANDOULAS+ (STEV,SETON,LEHI)

HAIDT 1  69 PL  29B 691        +(AACH,BARI,CERN,EPOL,NIJM,ORSAY,PADO,TORI)
HAIDT 2  69 PL 29B 696         +STEIN+(AACH+BARI+CERN+EPOL+NIJM+ORS+PA+TO)
HERZO    69 COO-1195-166       +BANNER,BEIER,BERTRAM,EDWARDS+        (ILL)
MACEK    69 PRL  22   32       MACEK,MANN,MC FARLANE,ROBERTS+(PENN,TEMPLE)
MAST     69 PR  183 1200       +GERSHWIN,ALSTON-GARNJOST,BANGERTER+  (LRL)
ZELLER   69 PR  182 1420       ZELLER,HADDOCK,HELLAND,PAHL+     (UCLA,LRL)

      QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BLOCK    62 CERN CONF 371      BLOCK,LENDINARA,MONARI        (NWU+BOLOGNA)

                    PAPERS NOT REFERRED TO IN DATA CARDS

BRENE    61 NP 22 553          BRENE,EGARDT,QVIST                    (NORD)
BIRGE    63 PRL  11  35        BIRGE,ELY,GIDAL,CAMERINI +   (LRL+WIS+BARI)
ADAIR    64 PL 12  67          ADAIR,LEIPUNER                    (YALE,BNL)
CABIBBO  64 PL   9 352         CABIBBO,MAKSYMOWICZ                   (CERN)
  ALSO   64 PL 11 360          CABIBBO,MAKSYMOWICZ                   (CERN)
  ALSO   65 PL 14  72          CABIBBO,MAKSYMOWICZ                   (CERN)
WILLIS   67 HEIDELBERG 273     W J WILLIS -RAPPORTEUR TALK           (YALE)
CRONIN   68 VIENNA CONF 241    RAPPORTEUR TALK                  (PRINCETON)

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K^0

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                 11  NEUTRAL K  (JP=0-)  I=1/2

                 11  KO MASS  (MEV)

M          498.1     0.4          CHRISTENS 64 OSPK
M    2223  497.44    0.33         KIM       65 HBC    KO FROM PBAR P   6/66
M    4500  498.9     0.5          BALTAY    66 HBC    KO FROM PBAR P   6/66
M          497.44    0.50         FITCH     67 OSPK                   11/67
M
M   AVG    497.87    0.32   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
M   FIT    497.76    0.16    VALUE FROM CONSTRAINED FIT                6/68
                     (SEE IDEOGRAM BELOW )

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                 11  KO-K CH. MASS DIFFERENCE (MEV)

D            3.9     0.6          ROSENFELD 59 HBC   -
D            5.4     1.1          CRAWFORD  59 HBC   +
D       9    3.90    0.25         BURNSTEIN 65 HBC   -
D       7    3.71  . 0.35         KIM       65 HBC   -  K- P TO KO N   6/68
D     417    3.95    0.21         HILL      68 DBC   +  K+D TO KOPP    3/68
D
D   AVG      3.92    0.14   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D   FIT      3.94    0.13    VALUE FROM CONSTRAINED FIT                6/68

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                             REFERENCES
                             11 NEUTRAL K (JP=0-)I=1/2
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CRAWFORD 59 PRL   2  112       CRAWFORD,CRESTI,GOOD,STEVENSON,TICHO  (LRL)
ROSENFEL 59 PRL   2  110       A H ROSENFELD,F SOLMITZ,R D TRIPP     (LRL)
CHRISTEN 64 PRL 13 138         CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
BURNSTEI 65 PR  138 B 895      R A BURNSTEIN,H A RUBIN          (MARYLAND)
KIM      65 PR 140 B 1334      J K KIM,L KIRSCH,D MILLER        (COLUMBIA)
BALTAY   66 PR 142   932       BALTAY,SANDWEISS,STONEHILL +     (YALE+BNL)
FITCH    67 PR 164  1711       FITCH,ROTH,RUSS,VERNON          (PRINCETON)
HILL     68 PR 168  1534       HILL,ROBINSON,SAKITT,CANTER  (BNL,CARNEGIE)
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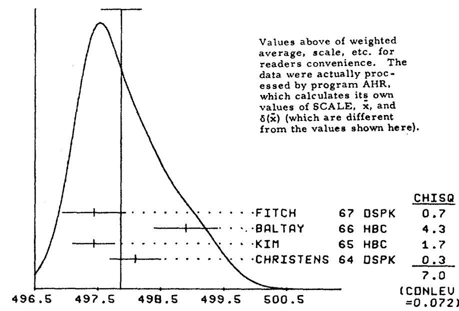
WEIGHTED AVERAGE = 497.87 ± 0.32
ERROR SCALED BY 1.5



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, $\bar{x}$, and $\delta(\bar{x})$ (which are different from the values shown here).

K^0_S

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                 12  SHORT-LIVED NEUTRAL K (498, JP=0-)  I=1/2

                 12  KOS LIFETIME (UNITS 10**-10)
T  O   90  (1.07)   (0.13)   (0.13) BOLDT     58 CC
T     512   0.94     0.05     0.05  CRAWFORD  59 HBC
T  O   63  (1.09)   (0.18)   (0.15) BOWEN     60 CC
T  O  OLD EXPTS WITH LOW STATISTICS NOT INCLUDED IN AVERAGE.              6/68
T     378   0.94     0.05     0.05  BERTANZA  62 HBC
T     503   0.87     0.05           CHRETIEN  63 HLBC
T     545   0.86     0.04           KREISLER  64 OSPK
T           0.866    0.016          ALFF-STEI 66 OSPK                     9/66
T     572   0.90     0.06     0.05  AUERBACH  66 OSPK                     8/67
T    4500   0.92     0.04           BALTAY    66 HBC                      6/66
T  B       (0.904)  (0.024)         BOTT-BODE 66 OSPK                     9/66
T  B  KOS LIFETIME NOT THE PRIMARY QUANTITY MEASURED IN THIS EXPT.        6/68
T    5000   0.843    0.013          KIRSCH    66 HBC                      6/66
T   19994   0.856    0.008          DONALD    68 HBC                      6/68
T   20000   0.865    0.009          HILL      68 DBC                      6/68
T  H   HILL 68 GIVES A DETAILED DISCUSSION OF SYSTEMATICS ENCOUNTERED IN
T  H   IN THIS TYPE OF EXPERIMENT.
T
T  AVG      0.8619   0.0062   0.0062  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
T  FIT      0.8619   0.0058   VALUE FROM CONSTRAINED FIT

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                 12  KOS PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     KOS INTO PI+ PI-                                 139+ 139
P2     KOS INTO PIO PIO                                 134+ 134
P3     KOS INTO MU+ MU-                                 105+ 105
P4     KOS INTO E+ E-                                    .5+  .5
P5     KOS INTO PI+ PI- GAMMA                           139+ 139+   0

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                 12  KOS  BRANCHING RATIOS

R1     KOS INTO (PI+ PI-)/TOTAL                             (P1)/TOTAL
R1          0.68     0.04           CRAWFORD  59 HBC
R1          0.70     0.08           COLUMBIA  60 HBC
R1  U      (0.740)  (0.024)         ANDERSON  62 HBC
R1  U                  UNPUBLISHED,NOT AVERAGED
R1
R1  AVG     0.684    0.036    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT     0.6871   0.0058    VALUE FROM CONSTRAINED FIT

R2     KOS INTO (PIO PIO)/TOTAL                             (P2)/TOTAL
R2          0.27     0.11           CRAWFORD  59 HBC
R2          0.26     0.06           BAGLIN    60 HLBC
R2          0.30     0.035          BROWN     61 HLBC
R2   1066   0.335    0.014          BROWN     63 HLBC
R2    198   0.288    0.021          CHRETIEN  63 HLBC
R2
R2  AVG     0.316    0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R2  FIT     0.3129   0.0058    VALUE FROM CONSTRAINED FIT
                     (SEE IDEOGRAM BELOW )
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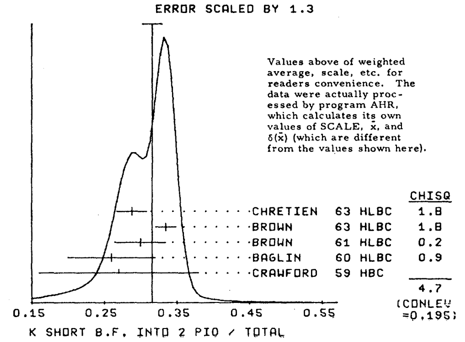
WEIGHTED AVERAGE = 0.316 ± 0.014
ERROR SCALED BY 1.3



Values above of weighted average, scale, etc. for readers convenience. The data were actually processed by program AHR, which calculates its own values of SCALE, $\bar{x}$, and $\delta(\bar{x})$ (which are different from the values shown here).

Data in parentheses have not been included in our averages.

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R3        KOS INTO (PI+ PI-)/(PIO PIO)                    (P1/P2)
R3    3016    2.285     0.055           GOBBI     69 OSPK   K+N TO KOP        5/69*
R3    3700    2.10      0.06            MORFIN    69 HLBC   K+N TO KOP       10/69*
R3          . . . . . . . . . .
R3   AVG      2.201     0.092   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
R3   FIT      2.196     0.060    VALUE FROM CONSTRAINED FIT

R4      (KOS INTO PI+ PI- PIO)/(KOL INTO PI+ PI- PIO)
R4    CPT ASSUMED TO BE GOOD - ONLY (IM A)**2 QUOTED HERE
R4           (3.8) OR LESS              ANDERSON  65 HBC     90 PERCENT CL    10/69*
R4           (0.45)OR LESS              BEHR      66 HLBC    90 PER CT CONF    8/66
R4           (9.0) OR LESS              BERLEY    69 HBC     90 PERCENT CL    10/69*
R4           (1.7) OR LESS              WEBBER 1  69 HBC     90 PERCENT CL    10/69*
R4   C       (0.8) OR LESS              WEBBER 1  69 HBC     90 PERCENT CL    10/69*
R4   C      THIS IS THE COMBINED RESULT OF ANDERSON 65 AND WEBBER 1 69

R5      KOS INTO (MU+ MU-)/CHARGED  (UNITS 10**-5)        (P3)/(P1)
R5          (10.0)  OR LESS             BOTT-BODE 67 OSPK     90 PER CT CONF   8/67
R5            (.031)OR LESS             FOETH     69 CNTR    90 PER CT CONF   10/69*
R5           (1.07) OR LESS             HYAMS     69 OSPK    90 PER CT CONF   10/69*
R5   S      (32.6)  OR LESS             STUTZKE   69 OSPK    90 PER CT CONF    5/69*
R5   S     VALUE CALCULATED BY US,USING 2.3 INSTEAD OF 1 EVENT, 90 PERC.CL   10/69*

R6      KOS INTO (E+ E-)/CHARGED    (UNITS 10**-5)        (P4)/(P1)
R6            (.022)  OR LESS           FOETH     69 CNTR    90 PER CT CONF   10/69*

R7      KOS INTO (PI+ PI- GAMMA)/(PI+ PI-) (UN.10**-3)  (P5)/(P1)
R7      27        NO RATIO GIVEN        BELLOTTI  66 HBC     PG GT 50 MEV/C   10/69*
R7      10    3.3       1.2             WEBBER    69 HBC     PG GT 50 MEV/C   10/69*

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REFERENCES

12 SHORT-LIVED NEUTRAL K (498, JP=0-) I=1/2


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BOLDT    58 PRL    1  150       E BOLDT,D O CALDWELL,Y PAL                (MIT)
CRAWFORD 59 PRL    2  266       CRAWFORD,CRESTI,DOUGLASS,GOOD,TICHO + (LRL)

BAGLIN   60 NC    18 1043       BAGLIN,BLOCH,BRISSON,HENNESSY +  (PARIS EP)
BOWEN    60 PR   119 2030       BOWEN,HARDY,REYNOLDS,SUN,MOORE+(PRINCE+BNL)
COLUMBIA 60 ROCH CONF 727       M SCHWARTZ +                      (COLUMBIA)

BROWN    61 NC    19 1155       BROWN,BRYANT,BURNSTEIN,GLASER,KADYK+ (MICH)
ANDERSON 62 CERN CONF 836       J A ANDERSON,F S CRAWFORD +            (LRL)
BERTANZA 62 PREPRINT 0105       BERTANZA,CONNOLLY,CULWICK,EISLER +     (BNL)
         (BERTANZA UNPUBLISHED,BUT RECERTIFIED BY AUTHORS,AUGUST 66)

BROWN    63 PR   130  769       BROWN,KADYK,TRILLING,ROE +   (LRL+MICHIGAN)
CHRETIEN 63 PR   131 2208       CHRETIEN+      (BRANDEIS+BROWN+HARVARD+ MIT)
KREISLER 64 PR   136 B 1074     M KREISLER,O OVERSETH,J CRONIN  (PRINCETON)
ANDERSON 65 PRL 14 475          +CRAWFOR,GOLDEN,STERN,BINFORD +  (LRL+WISC)

ALFF-STE 66 PL 21 595           ALFF-STEINBERGER,HEUER,KLEINKNECHT + (CERN)
AUERBACH 66 PR 149 1052         AUERBACH,DOBBS,LANDE,MANN,SCIULLI+    (PENN)
         SEE ALSO AUERBACH 65
BALTAY   66 PR 142    932       BALTAY,SANDWEISS,STONEHILL +      (YALE+BNL)
BEHR     66 PL    22  540       BEHR,BRISSON,PETIAU+ (EP,MILAN,PADUA,ORSAY)
BELLOTTI 66 NC 45A 737          +PULLIA,BALDO-CEOLIN +         (MILAN+PADUA)
BOTT-BOD 66 PL    23 277        BOTT-BODENHAUSEN,DE BOUARD +          (CERN)
KIRSCH   66 PR   147  939       L KIRSCH,P SCHMIDT                (COLUMBIA)
BOTT-BOD 67 PL 24B 194          BOTT-BODENHAUSEN,DE BOUARD,CASSEL+    (CERN)

DONALD   68 PL 27B 58           DONALD,EDWARDS,NISAR+(LIVERPOOL,CERN,PARIS)
HILL     68 PR 171 1418         HILL,ROBINSON,SAKITT +        (BNL,CARNEGIE)
BERLEY   69 CERN 69-7 339       +YAMIN,KOFLER,MANN+         (BNL+MASS+YALE)
FOETH    69 PL 30B 282          +HOLDER,RADERMACHER,RUBBIA+  (AACH+CERN+TO)
GOBBI    69 PRL 22 682          GOBBI,GREEN,HAKEL,MOFFETT,ROSEN+(ROCHESTER)
HYAMS    69 PL   29B 521        +KOCH,POTTER,VON LINDERN,LORENZ+ CERN(MPIM)
MORFIN   69  PRL   23  660      MORFIN,SINCLAIR                  (ANN ARBOR)
STUTZKE  69  PR   177  2009     +ABASHIAN,JONES,MANTSCH,ORR,SMITH(ILLINOIS)
WEBBER   69 UCRL 19226 THESIS B R WEBBER                               (LRL)
WEBBER 1 69 UCRL 19396          WEBBER,CRAWFORD +                      (LRL)
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PAPERS NOT REFERRED TO IN DATA CARDS


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BIRGE    60 ROCH CONF 601       R W BIRGE,P P ELY +          (LRL+WISCONSIN)
MULLER   60 PRL    4  418       MULLER,BIRGE,FOWLER,GOOD,PICCIOMI+(LRL+BNL)
FITCH    61 NC    22 1160       V FITCH,P PIRCUE,R PERKINS    (PRINCE+LASL)
GOOD     61 PR  124 1223        GOOD,MATSEN,MULLER,PICCIONI +          (LRL)
CRAWFORD 62 CERN CONF 827       F S CRAWFORD                           (LRL)
AUERBACH 65 PRL 14 192          AUERBACH,LANDE,MANN,SCIULLI,UTO +     (PENN)
TRILLING 65 UCRL 16473          GEORGE H TRILLING                      (LRL)
TRILLING 65   IS UPDATED FROM 1965 ARGONNE CONF , PAGE 115
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K_L^0

13 LONG-LIVED NEUTRAL K (498, JP=0-) I=1/2

13 KOL-KOS MASS DIFFERENCE
(UNITS ARE INVERSE KOS LIFETIME)

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D            (1.9)    (0.3)               FITCH     61 CNTR
D             0.84     0.29        0.21 GOOD      61 HLBC
D             0.88     0.20              CAMERINI  62 HLBC   SEE NOTE C BELOW  8/67
D    C  VALUE CHANGED FROM 1.5 (SEE TABLE 1 OF CAMERINI 66)                    8/67
D             0.47     0.21              AUBERT    65 HLBC                      6/66
D             0.26     0.36        0.26 BALDO-CEO 65 HLBC   ASS.CP CONS.
D             0.55     0.1               CHRISTENS 65 OSPK                      6/66
D            (0.60) OR LESS              FITCH     65 OSPK   CF. MEISNER 66    7/66
D    V  130  (0.82)   (0.14)             VISHNEVSK 65 OSPK   CU AND AL REGEN   8/67
D    V  VISHNEVSKY 65 NOT CORRECTED FOR INTERFERENCE EFFECTS                   3/68
D             0.445    0.034             ALFF-STEI 66 OSPK                      6/66
D       84    0.36     0.21        0.31  BALDO-CEO 66 HLBC   KO+N INTO HYPER.  8/67
D             0.480    0.024             BOTT-BODE 66 OSPK                      9/66
D       77    0.50     0.15              CAMERINI  66 HBC, DBC KO+N INTO HYPER 8/67
D    N  72 (+ 0.54)   (0.15)             CANTER    66 DBC    KO SCATTER IN D2 11/66
D    N      ERROR IGNORES UNCERTAINTY OF PHASE SHIFTS
D       95    0.54     0.09        0.14  CHANG     66 HBC    KO+P INTO HYPER.  8/67
D             0.72     0.15              FUJII     66 OSPK   IRON REGENERATOR  9/66
D    C  89   (0.62)   (0.16)             HILL      66 DBC    KO+D INTO HYPER.  9/66
D       59    0.65     0.30              MEISNER1  66 HBC    SEE NOTE M1       6/66
D    M1     + SIGN FAVORED               MEISNER2  66 HBC                      9/66
D      136  + 0.55     0.16              CANTER    67 DBC    KO+D INTO HYPER. 11/67
D            +0.35     0.15              JOVANOVIC 66 OSPK   C+URANIUM REGEN. 11/66
D             0.57     0.10              MISCHKE   67 OSPK                     11/67
D      590    0.53     0.12              BALATZ    68 OSPK   AL REGENERATOR    3/68
D             0.445    0.038             CARNEGIE  68 HBC    GAP METHOD        3/68
D            +0.42     0.04              MELHOP    68 OSPK   ST.STEEL REGEN    6/68
D             0.491    0.033             FAISSNER  69 ASPK   REGEN IN CU      10/69*
D          . . . . . . . . . .
D    AVG      0.473    0.014    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                               (SEE IDEOGRAM BELOW )
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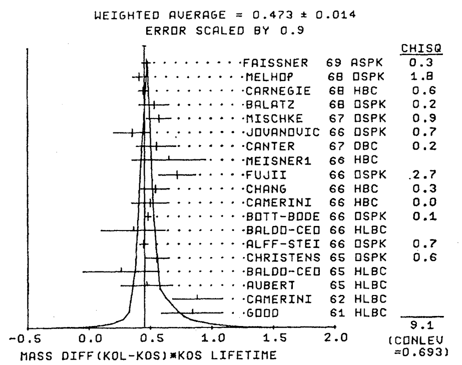


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NEUTRAL K CONSTRAINED FIT
OVERALL FIT OF LIFETIME, WIDTHS AND BRANCHING RATIOS USES 52 DATA POINTS TO DETERMINE SEVEN QUANTITITES. OVERALL FIT HAS CHISQ=51. VALUES OF BRANCHING RATIOS CHANGED MAINLY BECAUSE OF NEW MEASUREMENT OF R10 (EVANS 69). W2 AND W5 ARE RESPONSIBLE FOR THE LARGE SCALE FACTOR IN WIDTHS AND LIFETIME.

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                  13  KOL LIFETIME                (MICROSEC)

T       ASSUMED DS=DQ AND DELTA I=1/2 CRAWFORD  59 HBC
T        34     0.081     0.032     0.024 BARDON    58 CC
T        15     0.051     0.024     0.013 DARMON    62 FBC
T               0.053     0.006           FUJII     64 OSPK                     8/67
T      1700     0.061     0.015     0.012 ASTBURY3  65 CC                       8/67
T               0.0515    0.0014          DEVLIN    67 CNTR                     8/67
T    L         (0.050)   (0.005)          LOWYS     67 HLBC    SEE NOTE L BELOW 8/67
T    L  SUM OF PARTIAL DECAY RATES
T           . . . . . . . . . .
T    AVG        0.0520    0.0014    0.0013  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
T    FIT        0.0538    0.0019    VALUE FROM CONSTRAINED FIT

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                  13  KOL PARTIAL DECAY MODES

                                                           DECAY MASSES
P1      KOL INTO 3PIO                                     134+ 134+ 134
P2      KOL INTO PI+ PI- PIO                              139+ 139+ 134
P3      KOL INTO PI MU NEUTRINO                           139+ 105+   0
P4      KOL INTO PI E NEUTRINO                            139+  .5+   0
P5      KOL INTO PI+ PI-                                  139+ 139
P6      KOL INTO MU+ MU-                                  105+ 105
P7      KOL INTO E+ E-                                     .5+  .5
P8      KOL INTO E MU                                      .5+ 105
P9      KOL INTO TWO GAMMAS                                 0+   0
P10     KOL INTO PI+ PI- GAMMA                            139+ 139+   0
P11     KOL INTO PIO PIO                                  134+ 134

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                  13  KOL DECAY RATES

W1      KOL INTO PIO PIO PIO         (UNITS 10**6 SEC-1)  (P1)
W1       54    5.22    1.03         0.84  BEHR      66 HLBC    ASSUMES CP       8/66
W1          . . . . . . . . . .
W1   FIT       3.99      0.20       VALUE FROM CONSTRAINED FIT

W2      KOL INTO PI+ PI- PO          (UNITS 10**6 SEC-1)  (P2)
W2       18    3.26      0.77             ANDERSON  65 HBC                      8/66
W2       14    1.4       0.4              FRANZINI  65 HBC                      6/66
W2      136    2.62      0.28       0.27  BEHR      66 HLBC    ASSUMES CP       8/66
W2             2.54      0.43             HILL      66 DBC                      9/66
W2          . . . . . . . . . .
W2   AVG       2.36      0.32     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
W2   FIT       2.345     0.099      VALUE FROM CONSTRAINED FIT
                        (SEE IDEOGRAM BELOW )

W3      KOL INTO PI E NEUTRINO       (UNITS 10**6 SEC-1)  (P4)
W3             7.52      0.85       0.72  AUBERT    65 HLBC    DS=DQ,CP ASSUMED 8/67
W3          . . . . . . . . . .
W3   FIT       7.22      0.29       VALUE FROM CONSTRAINED FIT

W4      KOL INTO CHARGED (3-BODY)    (UNITS 10**6 SEC-1)  (P2+P3+P4)
W4       98   15.1       1.9              AUERBACH  66 OSPK                     8/67
W4          . . . . . . . . . .
W4   FIT      14.55      0.53       VALUE FROM CONSTRAINED FIT

W5      KOL INTO LEPTONIC (KMU3+KE3) (UNITS 10**6 SEC-1) (P3+P4)
W5      109    9.4       1.3              FRANZINI  65 HBC                      6/66
W5       54   11.3       1.9              GOLDEN    66 HBC                      9/66
W5      335   10.3       0.8              HILL      67 DBC     K+N TO KO P      8/67
W5          . . . . . . . . . .
W5   AVG      10.19      0.64     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
W5   FIT      12.20      0.45       VALUE FROM CONSTRAINED FIT

W6      KOL INTO PI MU NEUTRINO       UNITS 10**6 SEC-1)   (P3)
W6       19    4.54      1.24       1.08  LOWYS     67 HLBC                     8/67
W6          . . . . . . . . . .
W6   FIT       4.98      0.22       VALUE FROM CONSTRAINED FIT

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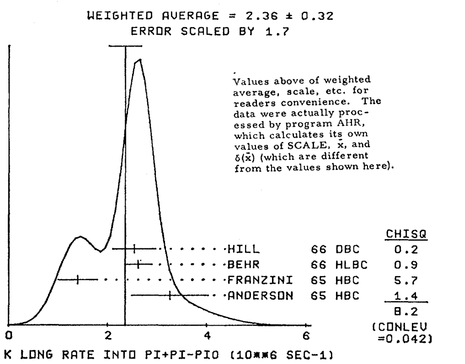
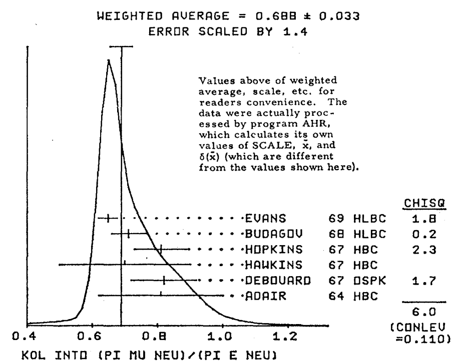
See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.





13 KOL BRANCHING RATIOS

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R1      KOL INTO (PIO PIO PIO)/CHARGED                     (P1)/(P2+P3+P4)
R1     24    0.24     0.08              ANIKINA   64 CC                            6/66
R1           0.31     0.06              KULYUKINA 66 CC                            9/66
R1    549    0.251    0.014             BUDAGOV   68 HLBC    ORSAY MEASUR.        10/68
R1    444    0.277    0.021             BUDAGOV   68 HLBC    EC. POLYTEC.MEAS     10/68
R1          . . . . . . . . . .
R1  AVG      0.260    0.011   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT      0.275    0.011    VALUE FROM CONSTRAINED FIT

R2      KOL INTO (PI+ PI- PIO)/CHARGED                     (P2)/(P2+P3+P4)
R2     59    0.185    0.038             ASTIER    61 CC                            8/66
R2     79    0.151    0.020             ADAIR     64 HBC                           8/66
R2     75    0.157    0.03      0.04    LUERS     64 HBC                           8/66
R2     66    0.15     0.03      0.04    ASTBURY1  65 CC                            8/66
R2    326    0.159    0.015             ASTBURY2  65 CC                            6/66
R2    566    0.178    0.017             GUIDONI   65 HBC                           6/66
R2   1729   (0.144)  (0.004)            HOPKINS   65 HBC     SEE HOPKINS 67        6/66
R2    126    0.162    0.015             HAWKINS   66 HBC                           6/66
R2    180    0.17     0.03              KULYUKINA 66 CC                            9/66
R2           0.161    0.005             HOPKINS   67 HBC                           8/67
R2    558    0.157    0.010             EVANS     69 HLBC                         10/69*
R2          . . . . . . . . . .
R2  AVG      0.1611   0.0038  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT      0.1612   0.0037   VALUE FROM CONSTRAINED FIT

R3      KOL INTO (PI MU NEUTRINO)/CHARGED                  (P3)/(P2+P3+P4)
R3  C  251  (0.356)  (0.07)             LUERS     64 HBC
R3  C  172  (0.39)   (0.08)    (0.10)   ASTBURY1  65 CC                            7/66
R3  C  330  (0.32)   (0.07)             KULYUKINA 66 CC                            9/66
R3  C THIS MODE NOT MEASURED INDEPENDENTLY FRCM R2 AND R4
R3          . . . . . . . . . .
R3  FIT      0.3423   0.0083   VALUE FROM CONSTRAINED FIT

R4      KOL INTO (PI E NEUTRINO)/CHARGED                   (P4)/(P2+P3+P4)
R4    153    0.487    0.05              LUERS     64 HBC
R4    202    0.46     0.08      0.10    ASTBURY1  65 CC                            7/66
R4    500    0.51     0.06              KULYUKINA 66 CC                            9/66
R4          . . . . . . . . . .
R4  AVG      0.491    0.035   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R4  FIT      0.4965   0.0084   VALUE FROM CONSTRAINED FIT

R5      KOL INTO (PI E NEU)/((PI E NEU)+(PI MU NEU))       (P4)/(P3+P4)
R5    320    0.415    0.120             ASTIER    61 CC
R5          . . . . . . . . . .
R5  FIT      0.5919   0.0097   VALUE FROM CONSTRAINED FIT

R6      KOL INTO(PI+ PI- PIO)/TOTAL                        (P2)/TOTAL
R6
R6          . . . . . . . . . .
R6  FIT      0.1261   0.0029   VALUE FROM CONSTRAINED FIT

R7      KOL INTO(LEPTON PI NEUTRINO)/TOTAL                 (P3+P4)/TOTAL
R7
R7          . . . . . . . . . .
R7  FIT      0.6563   0.0069   VALUE FROM CONSTRAINED FIT

R8        KOL INTO (2 GAMMA)/TOTAL     (UN. 10**-4)        (P9)/TOTAL
R8  C        (1.3)    (0.6)             CRIEGEE   66 OSPK                          8/66
R8     32    6.7      2.2               TODOROFF  67 OSPK    REPL. CRIEGEE66      11/68
R8     33    7.4      1.6               CRONIN 1  67 OSPK                         11/67
R8  C     CRIEGEE 66 REPLACED BY TODOROFF 67                                      11/68
R8          . . . . . . . . . .
R8  AVG      7.2      1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R9      KOL INTO (PI+ PI-)/CHARGED     (UNIT 10**-3)       (P5)/(P2+P3+P4)
R9     45    2.0      0.4               CHRISTENS 64 OSPK ETA +- = 1.94
R9     54    2.08     0.35              GALBRAITH 65 OSPK ETA +- = 2.02
R9           1.93     0.26              BASILE    66 OSPK ETA +- = 1.86            9/66
R9           1.993    0.080             BOTT-BODE 66 OSPK ETA +- = 1.935           9/66
R9          . . . . . . . . . .
R9  AVG      1.992    0.073   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R9  FIT      2.001    0.063    VALUE FROM CONSTRAINED FIT

R10     KOL INTO (PI MU NEU)/(PI E NEU)                    (P3)/(P4)
R10          0.81     0.19              ADAIR     64 HBC                           6/66
R10          0.82     0.10              DEBOUARD  67 OSPK    SEE NOTE N BELOW     11/67
R10   273    0.7      0.2               HAWKINS   67 HBC                           8/67
R10          0.81     0.08              HOPKINS   67 HBC                           8/67
R10         (0.625)  (0.04)             BASILE1   68 OSPK                         10/68
R10   770    0.71     0.05              BULAGOV   68 HLBC                         10/68
R10         (0.71)   (0.04)             BEILLIERE 69 HLBC                         10/69*
R10  1309    0.648    0.030             EVANS     69 HLBC                         10/69*
R10         . . . . . . . . . .
R10 AVG      0.688    0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R10 FIT      0.689    0.028    VALUE FROM CONSTRAINED FIT
                      (SEE IDEOGRAM BELOW )

R11     KOL INTO (MU+MU-)/CHARGED   (UNITS 10**-6)         (P6)/(P2+P3+P4)
R11        (100.0)OR LESS               ANIKINA   65 CC                            6/66
R11         (50.0)   OR LESS            ABASHIAN  66 OSPK    90 PER CT CONF        8/66
R11        (250.0)  OR LESS             ALFF-STEI 66 OSPK    0.90 CONF. LEVEL      9/66
R11          (2.0)  OR LESS             BOTT-BODE 67 OSPK     90 PER CT CONF       8/67
R11         (35.0)  OR LESS             FITCH     67 OSPK    90 PER CT CONF        3/68

R12       KOL INTO (PI+ PI- GAMMA)/TOTAL (UNITS 10**-3)    (P10)/TOTAL
R12         (15.0)OR LESS               ANIKINA   65 CC                            6/66
R12     0    (5.0) OR LESS              BELLOTTI  66 HLBC    GAM KE 40-130 MV      8/67
R12     1    (3.0)OR LESS               NEFKENS   66 OSPK    GAM KE 120 MEV        6/66
R12          (0.4)OR LESS               THATCHER  68 OSPK    90 PER CT CONF       10/68

R13       KOL INTO (E+ E-)/CHARGED     (UNITS 10**-6)      (P7)/(P2+P3+P4)
R13       (1000.0)OR LESS               ANIKINA   65 CC                            6/66
R13         (50.0) OR LESS              ABASHIAN  66 OSPK     90 PRCT CONF         6/66
R13        (200.0) OR LESS              ALFF-STEI 66 OSPK    90 PRCT CONF          6/66
R13         (23.0)  OR LESS             BOTT-BODE 67 OSPK     90 PER CT CONF       8/67

R14       KOL INTO (E MU)/CHARGED      (UNITS 10**-4)      (P8)/(P2+P3+P4)
R14         (10.0)  OR LESS             ANIKINA   65 CC                            6/66
R14          (1.0)   OR LESS            CARPENTER 66 OSPK    90 PER CT CONF        8/66
R14          (0.107)OR LESS             BOTT-BODE 67 OSPK     90 PER CT CONF       8/67
R14          (0.08) OR LESS             FITCH     67 OSPK    90 PER CT CONF        3/68

R15     KOL INTO(E+ PI- NEU)/(E- PI+ NEU)
R15 O   97   (0.90)   (0.18)            NEAGU     61 CC
R15 O        (1.01)   (0.16)            LUERS     64 HBC                           8/66
R15 O  894   (0.99)   (0.023)           KULYUKINA 66 CC                            9/66
R15 O 1539   (1.06)   (0.05)            VERHEY    66 OSPK                          8/67
R15 O   LOW PRECISION EXPTS NOT AVERAGED.  FOR MORE PRECISE VALUE,
R15 O   SEE S1302 (BENNETT 67)

R16     KOL INTO(MU+ PI- NEU)/(MU- PI+ NEU)
R16   3200    1.02    0.04              ABASHIAN  66 OSPK                          8/66
R16  10**6    1.0081  0.0027            DORFAN    67 OSPK                         11/67

R17         KOL INTO (PIO PIO)/TOTAL  (UNITS 10**-3)       (P11)/TOTAL
R17 C    7   (1.2)    (1.5)    (1.2)    CRIEGEE   66 OSPK                          7/66
R17 C   CRIEGEE EXPT NOT DESIGNED TO MEASURE 2 PIO DECAY MODE
R17    189    2.5      0.8              GAILLARD  69 OSPK    E00=3.6+-0.6          5/69*
R17         . . . . . . . . . .
R17 FIT       1.21     0.30     VALUE FROM CONSTRAINED FIT

R18       KOL INTO (3PIO)/(PI+PI-PIO)                      (P1)/(P2)
R18    188    2.0      0.6              ALEKSANYA 64 FBC                           9/66
R18   1010    1.80     0.13             BUDAGOV   68 HLBC                         10/68
R18         . . . . . . . . . .
R18 AVG       1.81     0.13     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R18 FIT       1.703    0.075     VALUE FROM CO:STRAINED FIT

R19     KOL INTO (2PIO)/(3PIO)          (UNITS 10**-2)     (P11)/(P1)
R19 C  109   (1.89)   (0.31)            CRONIN 1  67 OSPK    ETA00=4.9+-0.5        8/67
R19 C        (1.36)   (0.18)            CRONIN 2  67 OSPK    ETA00=3.92+-0.3      11/67
R19 C      CRONIN2 IS FURTHER ANALYSIS OF CRONIN1 ,NOW BOTH WITHDRAWN             11/68
R19     58    0.46     0.11             BANNER2   68 OSPK    ETA00=2.3+-0.3       10/68
R19     24    0.45     0.18             BUDAGOV1  68 HLBC    ETA00=2.2+-0.4       10/69*
R19     NO EVENTS SEEN                  BARTLETT  68 OSPK    SEE E00 BELOW        11/68
R19    133    1.31     0.31             CENCE     69 OSPK    ETA00=3.7+-0.5       10/69*
R19         . . . . . . . . . .
R19 AVG       0.53     0.17     AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.9)
R19 FIT       0.56     0.14      VALUE FROM CONSTRAINED FIT
                      (SEE IDEOGRAM BELOW )

R20     KOL INTO (PI+ PI-)/(KE3 + KMU3)  (UNITS 10**-3)  (P5)/(P3+P4)
R20    309    2.51     0.23             DEBOUARD  67 OSPK                          6/68
R20    525    2.35     0.19             FITCH     67 OSPK    ETA+-=1.91+-.06       6/68
R20         . . . . . . . . . .
R20 AVG       2.41     0.15     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.0)
R20 FIT       2.386    0.076     VALUE FROM CONSTRAINED FIT

R21     (2 GAMMA)/(3 PIO)  (UNITS 10**-3)                  (P9)/(P1)
R21     16    2.5      0.7              ARNOLD    68 HLBC    VACUUM DECAY         11/68
R21    115    2.24     0.28             BANNER1   68 OSPK    SEE NOTE B           11/68
R21 B  THIS IS NEW EXPER. -NOT TO BE CONF. WITH  R8 OF CRONIN1 67-                11/68
R21         . . . . . . . . . .
R21 AVG       2.28     0.26     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.0)

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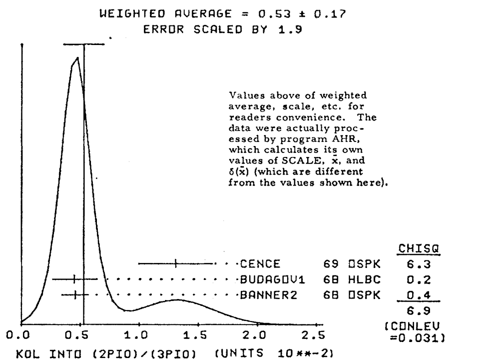
See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.



Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients $= \langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.215+-.007					
P 2	-.229	.126+-.003				
P 3	-.375	-.090	.268+-.007			
P 4	-.486	-.089	-.552	.388+-.008		
P 5	-.276	.028	.107	.138	.002+-.000	
P 6	.124	-.043	-.061	-.080	-.046	.001+-.000

Fitted Partial Decay Rates

Diagonal elements are $W_i \pm \delta W_i$; $W_i = \Gamma_{total} P_i$; $\delta W_i = \sqrt{\langle \delta W_i \delta W_i \rangle}$. Off-diagonal elements are correlation coefficients $= \langle \delta W_i \delta W_j \rangle / (\delta W_i \cdot \delta W_j)$.

	W 1	W 2	W 3	W 4	W 5	W 6
W 1	3.99+- .20					
W 2	.553	2.35+- .10				
W 3	.471	.646	4.98+- .22			
W 4	.511	.705	.549	7.22+- .29		
W 5	.435	.622	.636	.686	.029+-.001	
W 6	.201	.110	.093	.101	.086	.023+-.005

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13 KO2 FORM FACTORS

FOR DISCUSSION OF FORM FACTORS SEE NOTE PRECEDING K+ FORM FACTORS

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XIA      XIA = F-/F+ (DETERMINED FROM SPECTRA AND KMU3/KE3)   --------------
XIA
XIA       UNLESS OTHERWISE NOTED, THE EXPERIMENTS BELOW EVALUATE
XIA       XI ASSUMING THAT IT IS INDEPENDENT OF MOMENTUM TRANSFER,
XIA       I.E. THEY SET LM+=LM-=0 AND REPORT THEIR RESULT AS XI AT T=0.
XIA       IN REALITY, HOWEVER, THEY HAVE MEASURED XI OVER SOME
XIA       REGION WHERE T IS NOT ZERO
XIA       THE AVERAGE MADE BELOW IGNORES THAT T DEPENDENCE.

XIA L  389  (+1.1)    (0.9)    (1.3)  ADAIR      64 HBC      KMU3/KE3           8/67
XIA L       (+0.66)   (0.9)    (1.3)  LUERS      64 HBC      KMU3/KE3           8/67
XIA   1371  (+1.2)    (0.8)           CARPENTER 66 OSPK     MU,PI SPECTRA      8/67
XIA  C1371   -0.82     0.6            CARPENTER 66 OSPK     MU,PI SPECTRA.C.   8/67
XIA  C     2ND CARPENTER VALUE ALLOWS ENERGY DEP OF F+,F-
XIA          -0.2      1.0      1.7   KULYUKINA 66 CC       MU,PI SPECTRA      8/67
XIA         (-3.9)    (0.1)           BASILE1    68 OSPK +  DALITZ PLOT       10/68
XIA         (-0.4)    (0.3)           BASILE1    68 OSPK +  KMU3/KE3          10/68
XIA    770   +0.3     +0.4            BUDAGOV    68 HLBC    KM3/KE3,LM+=.023 11/68
XIA   1309   -0.22     0.30           EVANS      69 HLBC    KM3/KE3,LM+=.02  10/69*
XIA L    LM+ AND LM- ASSUMED TO BE ZERO - NOT AVERAGED
XIA          . . . . . . . . . .
XIA AVG      -0.14     0.25    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

XIB      XIB = F-/F+ (DETERMINED FROM MU POLARIZATION IN KMU3)   -----------
XIB      MEAS OF XI USING POLARIZATION IS LESS SENSITIVE TO FORM FACTOR
XIB      VARIATIONS.

XIB   2608   -1.2      0.5            AUERBACH   66 OSPK    POLARIZATION       8/67
XIB    638   -1.6      0.5            ABRAMS     68 OSPK    POLARIZATION       5/69*
XIB          -1.81     0.50     0.26  LONGO      69 CNTR    POL. T=2.65       11/69*
XIB          . . . . . . . . . .
XIB AVG      -1.59     0.26    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

RXI         REAL PART OF XI   (COMBINED XIA AND XIB)
RXI   1371  (+1.2)    (0.8)           CARPENTER 66 OSPK
RXI   1371   -0.82     0.6            CARPENTER 66 OSPK
RXI          -0.2      1.0      1.7   KULYUKINA 66 CC
RXI         (-3.9)    (0.1)           BASILE1    68 OSPK +
RXI         (-0.4)    (0.3)           BASILE1    68 OSPK +
RXI    770   +0.3     +0.4            BUDAGOV    68 HLBC
RXI   1309   -0.22     0.30           EVANS      69 HLBC
RXI   2608   -1.2      0.5            AUERBACH   66 OSPK
RXI    638   -1.6      0.5            ABRAMS     68 OSPK
RXI          -1.81     0.50     0.26  LONGO      69 CNTR
RXI          . . . . . . . . . .
RXI AVG      -0.75     0.35    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                       (SEE IDEOGRAM BELOW )
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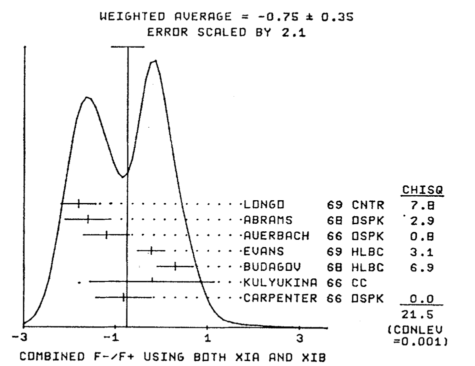


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IXI         IMAGINARY PART OF XI  (TEST OF T REVERSAL)   --------------------
IXI          -0.2      0.6                  ABRAMS     68 OSPK    MU POLARIZATION  10/69*
IXI          -0.02     0.08                 LONGO      69 CNTR    POL. T=2.65      11/69*
IXI          . . . . . . . . . .
IXI AVG      -0.023    0.079   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

FS       FS/F+ . RATIO OF SCALAR TO F+ COUPLINGS  (ABS. VALUE)   ------------
FS           (0.15)  OR LESS                KULYUKINA 67 CC       68 PERCENT CO.LE 10/69*

FT       FT/F+  RATIO OF TENSOR TO F+ COUPLINGS  (ABS. VALUE)   ------------
FT           (1.0)   OR LESS                KULYUKINA 67 CC       68 PERCENT CO.LE 10/69*

LM+      LAMBDA +  (LINEAR ENERGY DEPENDENCE OF F+ IN KO E3 DECAY)   ------
LM+      FOR RAD. CORR. TO THE DALITZ PLOT OF KE3, SEE GINSBERG 67.

LM+    153   +0.07     .06                  LUERS      64 DLTZ PLT,NO RAD CORR
LM+    577   +0.15     .08                  FISHER     65 OSPKDLTZ PLT,NO RAD CORR  8/67
LM+    762   -0.01     .02                  FIRESTONE 67 HBC DLTZ PLT,NO RAD CORR  8/67
LM+    531   +0.01     .015                 KADYK      67 HBC E,PI SPEC,NO RAD COR  8/67
LM+    240   +0.08     .10        .08       LOWYS      67 FRC PI  SPEC, RAD CORR    8/67
LM+   1000    0.02    0.013                 ARONSON    68 OSPK    PI SPECTRUM       5/69*
LM+   4800   +0.023   0.012                 BASILE     68 OSPK DLTZ PLT,NO RAD COR  3/68
LM+          . . . . . . . . . .
LM+ AVG       0.0172  0.0070  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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13 NEUTRAL K ENERGY DEPENDENCE OF DALITZ PLOT

MATRIX ELEMENT SQUARED = 1 + G (S3-S0)/(MPI+**2)

```
GTO  LINEAR ENERGY DEPENDENCE (G) FOR TAU DECAYS  KLONG INTO PIO PI+PI-

GTO   1350   (0.651)  (0.044)               HOPKINS    67 HBC                       10/69*
GTO   1198    0.437    0.057                NEFKENS    67 OSPK                      10/69*
GTO   2446    0.382    0.040                BASILE2    68 OSPK                      10/69*
GTO          . . . . . . . . . .
GTO AVG       0.400    0.033   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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13 X =(DS=-DQ AMPLITUDE /DS=+DQ AMPLITUDE)

```
REX        REAL PART OF X

REX  C 152    0.06     0.18      0.44  BALDO-CE   65 HLBC    K+ CHARGE EXCHNG 11/67
REX    196    0.035    0.11      0.13  AUBERT     65 HLBC    K+ CHARGE EXCHNG 11/67
REX  F 109   -0.08     0.16      0.28  FRANZINI   65 HBC     PBAR P           11/67
REX    335    0.17     0.10            HILL       67 DBC     K+D YIELDS KOPP  11/67
REX    116    0.17     0.16      0.35  FELDMAN    67 OSPK    PI-P TO KO LMBDA 11/67
REX  B       (0.03)   (0.03)          . BENNETT1  68 CNTR                       7/68
REX    121    0.09     0.07      0.09  JAMES      68 HBC     PBAR P            5/69*
REX  B       -0.020    0.025           BENNETT    69 CNTR    CHAR ASYM+ CU RE 10/69*
REX    686    0.09     0.14      0.16  LITTENBER 69 OSPK    K+N TO KOP        4/69*
REX    262    0.25     .07       .09   WEBBER     69 HBC     K-P TO KBAR N    10/69*
REX  B     BENNETT 69 IS A REANALYSIS OF BENNETT1 68
REX  C         BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX 11/67
REX  F         FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67 11/67
REX          . . . . . . . . . .
REX AVG       0.021    0.036   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                       (SEE IDEOGRAM BELOW )

IMX        IMAGINARY PART OF X (ASSUMES M(KL)-M(KS) POSITIVE -- SEE S13D)

IMX  C 152   -0.44     0.32      0.19  BALDO-CE   65 HLBC    K+ CHARGE EXCHNG  3/68
IMX    196   -0.21     0.11      0.15  AUBERT     65 HLBC    K+ CHARGE EXCHNG  3/68
IMX  F 109   +0.24     0.40      0.30  FRANZINI   65 HBC     PBAR P             3/68
IMX    116    0.0      0.25            FELDMAN    67 OSPK    PI-P TO KO LMBDA 11/67
IMX  H 335   -0.20     0.10            HILL       67 DBC     K+D YIELDS KOPP  11/67
IMX    121   +0.22     0.37      0.29  JAMES      68 HBC     PBAR P            5/69*
IMX    686   -0.11     0.10      0.11  LITTENBER 69 OSPK    K+N TO KOP        4/69*
IMX    262    0.0      .08             WEBBER     69 HBC     K-P TO KBAR N    10/69*
IMX  C         BALDO-CE 65 GIVES X AND THETA.CONVERTED BY US TO REX AND IMX 11/67
IMX  F         FRANZINI 65 GIVES X AND THETA.FOR REX AND IMX SEE SCHMIDT 67 11/67
IMX  H FTNOTE 10 OF HILL 67 SHOULD READ +0.58, NOT -0.58 (PRIV COMM)          3/68
IMX          . . . . . . . . . .
IMX AVG      -0.099    0.047   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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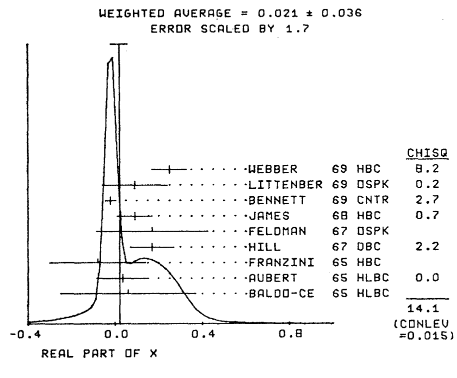
See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

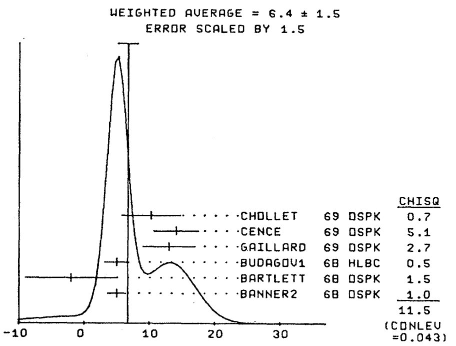


13 CP VIOLATION PARAMETERS

```
ETA+- = A(KL TO PI+PI-)/A(KS TO PI+PI-)
ETA00 = A(KL TO PI0PI0)/A(KS TO PI0PI0)

THE MAGNITUDES OF ETA+- AND OF ETA00 ARE DERIVED FROM BR. RATIOS.
FOR THE QUANTITIES MEASURED BY THE INDIVIDUAL EXPERIMENTS SEE LISTINGS
OF S13R9 AND S13R2 (ETA+-) AND OF S13R17 AND S13R19 (ETA00).
FOR THE READER'S CONVENIENCE WE LIST HERE THE DERIVED QUANTITIES ETA+-
(E+-) AND  (ETA00)**2 ,CALLED E0S

E0S      (ETA00)**2 = (A(KL TO 2PI0)/A(KS TO 2PI0))**2  (UNITS 10**-6)   ---
E0S    58    5.06      1.4              BANNER2   68 OSPK                   10/69*
E0S     0   -2.        7.0              BARTLETT  68 OSPK                   10/69*
E0S    24    5.05      1.9              BUDAGOV1  68 HLBC                   10/69*
E0S   180   13.        4.               GAILLARD  69 OSPK                   10/69*
E0S   133   14.1       3.4              CENCE     69 OSPK                   10/69*
E0S         10.3       4.5              CHOLLET   69 OSPK   CU REG.,4 GAMMAS 10/69*
E0S            . . . . . . . . .
E0S AVG      6.4       1.5    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW )
```

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E+-    ETA+-  = A(KL TO PI+PI-)/A(KS TO PI+PI-) UNITS 10**-3 -------------
E+-     45   (1.94)                   CHRISTENS 64 OSPK                     10/69*
E+-     54   (2.02)                   GALBRAITH 65 OSPK                     10/69*
E+-          (1.86)                   BASILE    66 OSPK                     10/69*
E+-          (1.935)                  BOTT-BODE 66 OSPK                     10/69*
E+-    525    1.91       .06          FITCH     67 OSPK                     10/69*

F+-    PHASE OF ETA +-         (DEGREES)  -------------------------------
F+-        DM IS KOL-KOS MASS DIFFERENCE IN UNITS OF INVERSE KOS LIFETIME
F+-           SEE SECTION D OF KOL LISTINGS FOR LATEST VALUE

F+-           45.0     50.0           FITCH     65 OSPK   BE REGEN          11/67
F+-           30.0     45.0           FIRESTONE 66 HBC                      11/67
F+-           70.0     21.0           BOTT-BODE 67 OSPK   C REGEN           11/67
F+-           25.0     35.0           MISCHKE   67 OSPK   CU REGEN           7/68
F+- N        (51.0)   (11.0)          BENNETT2  68 CNTR   CU REG. USES       8/68
F+-  C        34.9     10.0           BENNETT   69 CNTR   CU REGEN          11/69*
F+-  B        41.      15.            BOHM      69 OSPK   VACUUM REGEN      11/69*
F+-  F        49.3      8.5           FAISSNER  69 ASPK   CU REGEN          11/69*
F+-  J        40.0     12.5           JENSEN    69 ASPK   VACUUM REGEN      11/69*
F+-                 COMMENTS
F+-  B     DM DEPENDENCE OF BOHM 69 IS 556*(DM-0.454) DEG                   11/69*
F+-  C    BENNETT 69 USES MEASUREMENT OF (F+-)-(PHIF) OF ALFF-STEINBERGER66
F+-  C     DM DEPENDENCE OF BENNETT 69 IS 80*(DM-0.469) DEG                 11/69*
F+-  F     FAISSNER 69 ERROR ENLARGED TO INCLUDE ERROR IN REGENERATOR PHASE 11/69*
F+-  F     DM DEPENDENCE OF FAISSNER 69 IS 238*(DM-0.478) DEG               11/69*
F+-  J     DM DEPENDENCE OF JENSEN 69 IS 636*(DM-0.464) DEG                 11/69*
F+-  N     BENNETT 69 IS A REEVALUATION OF BENNETT2 68                      11/69*
F+-     ERRORS FOR BENNETT 69, BOHM 69, FAISSNER 69, AND JENSEN 69          11/69*
F+-     INCLUDE ERROR FROM UNCERTAINTY OF DM
F+-        . . . . . . . . .
F+- AVG       43.5      5.1    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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```
F00     PHASE OF ETA 00    (DEGREES)    ---------------------------------
F00          23.0      32.0           CHOLLET   69 OSPK   CU REG.,4 GAMMAS 10/69*
F00     FIRST QUADRANT PREFERRED      GOBBI     69 OSPK                    11/69*
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13 ASYMMETRY PARAMETERS

```
A      DECAY ASYMMETRY PARAMETER FOR PI+ PI- PI0    ----------------------
A     THIS PARAMETER TESTS THE VALIDITY OF BOTH THE DELTA-I = 1/2 RULE
A     AND THE CP-INVARIANCE IN KOL + PI+ PI- PI0.
A             .001      .004          BLANPIED  68 CNTR                    11/69*
```

13 CHARGE ASYMMETRY IN LEPTONIC DECAYS (PERCENT)
SUCH ASYMMETRY VIOLATES CP . IT IS RELATED TO REAL(EPSILON).

```
A1    KOL INTO (MU+PI-NU)-(MU-PI+NU)/(MU+PI-NU)+(MU-PI+NU)
A1   10**6    0.403     0.134         DORFAN    67 OSPK   DERIVED FROM R16 11/67

A2    KOL INTO (E+PI-NU)-(E-PI+NU)/(E+PI-NU)+(E-PI+NU)
A2   10**7    0.224     0.036         BENNETT   67 CNTR                    11/67
A2           (0.315)   (0.030)        KIRK      69 CNTR   PRELIMINARY      10/69*

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REFERENCES
13 LONG-LIVED NEUTRAL K (498, JP=0-) I=1/2


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BARDON   58 ANP 5 156          M BARDON,K LANDE,L LEDERMAN  (COLUMBIA+BNL)
CRAWFORD 59 PRL 2 361          CRAWFORD,CRESTI,DOUGLASS,GOOD +         (LRL)
ASTIER   61 AIX CONF 1 227     ASTIER,BLASKOVIC,RIVET,SIAUD +   (PARIS+EP)
FITCH    61 NC  22 1160        V FITCH,P PIROUE,R PERKINS       (PRINCETON)
GOOD     61 PR 124 1223        GOOD,MATSEN,MULLER,PICCIONI,POWELL +  (LRL)
NEAGU    61 PRL  6  552        NEAGU,OKONOV,PETROV,ROSANOVA,RUSAKOV (JINR)

CAMERINI 62 PR 128 362         CAMERINI,FRY,GAIDOS,BIRGE,ELY +  (WISC+LRL)
DARMON   62 PL 3 57            J DARMON,A ROUSSET,J SIX         (PARIS+EP)

ADAIR    64 PL 12 67           P K ADAIR,L B LEIPUNER            (YALE+BNL)
ALEKSANY 64 DUBNA 2 102        ALEKSANYAN,ALIKHANYAN,VARTAZARYAN+ (EREVAN)
  SEE ALSO  JETP 19 1019       ALEKSANYAN+    (LEBEDEV+MOS ENG PHYS+EREVAN)
ANIKINA  64 JETP 19 42         ANIKINA,ZHURAVLEVA+ (GEORG ACAD SCI+ DUBNA)
CHRISTEN 64 PRL 13 138         CHRISTENSON,CRONIN,FITCH,TURLAY  (PRINCETN)
FUJII    64 DUBNA 2 146        FUJII,JOVANOVICH,TURKOT+ (BNL,MARYLAND,MIT)
LUERS    64 PR 133 B 1276      LUERS,MITTRA,WILLIS,YAMAMOTO            (BNL)

ANIKINA  65 JINR P 2488        ANIKINA,VARDENGA,ZHURAVLEVA,KOTLYA+ (DUBNA)
ANDERSON 65 PRL 14 475         ANDERSON,CRAWFORD,GOLDEN,STERN + (LRL+WISC)
ASTBURY1 65 PL 16 80           ASTBURY,FINOCCHIARO,BEUSCH +  (CERN+ZURICH)
ASTBURY1 65  SEE ALSO M PEPIN  HELV.PHYS. ACTA 39 523
ASTBURY2 65 PL 18 175          ASTBURY,MICHELINI,BEUSCH +     (CERN+ZURICH)
ASTBURY3 65 PL 18 178          ASTBURY,MICHELINI,BEUSCH +     (CERN+ZURICH)

AUBERT   65 PL 17 59           AUBERT,BEHR,CANAVAN,CHOUNET+  (PARIS+ORSAY)
AUBERT   65  SEE ALSO LOWYS 67
BALDO-CE 65 NC 38 684          BALDO-CEOLIN,CALIMANI,CIAMPOLILLO + (PADVA)
CHRISTEN 65 PR 140 B 74        CHRISTENSON,CRONIN,FITCH,TURLAY (PRINCETON)
  (CHRISTENSON 65 HAS BEEN CORRECTED FOR INTERFERENCE BY FITCH 65, FOOTNOTE)

FISHER   65 ANL 7130 83       FISHER,ABASHIAN,ABRAMS,CARPENTER+(ILLINCIS)
FITCH    65 PRL 15 73          FITCH,ROTH,RUSS,VERNON           (PRINCETON)
FRANZINI 65 PR 140 B 127       FRANZINI,KIRSCH,PLANO +  (COLUMBIA+RUTGERS)
GALBRAIT 65 PRL 14 383         GALBRAITH,MANNING,JONES + (AERE+BRIST+RHEL)

GUIDONI  65 ARGONNE CONF 49    +BARNES,FOELSCHE,FERBEL,FIRESTO+ (BNL+YALE)
HOPKINS  65 ARGONNE CONF 67    H W K HOPKINS,BACON,EISLER   (VAND+RUTGERS)
VISHNEVS 65 PL  18   339       VISHNEVSKY,GALANINA,SEMENOV +      (MOSCOW)

ABASHIAN 66 BERKELEY 28        ABASHIAN,ABRAMS,VERHEY+ // URBANA
ALFF-STE 66 PL 21 595          ALFF-STEINBERGER,HEUER,RUBBIA +      (CERN)
AUERBACH 66 PRL  17  980       AUERBACH,MANN,MCFARLANE,SCIULLI      (PENN)
AUERBACH 66 PR  149 1052       AUERBACH,DOBBS,LANDE,MANN,SCIULLI+   (PENN)
AUERBACH 66   SEE ALSO PRL 14 192
BALDO-CE 66 NC  45A  733       BALDO-CEOLIN,CALIMANI,CIAMPOLILLO+  (PADUA)
BASILE   66  BALATON CONF      BASILE,CRONIN,THEVENET +           (SACLAY)

BEHR     66 PL   22  540       BEHR,BRISSON,BALDO-CEOLIN,AUBERT+(PADUA,EP)
BELLOTTI 66 NC   45A  737      BELLOTTI,PULLIA,BALDO-CEOLIN+ (MILAN,PADUA)
BOTT-BOD 66 PL   23  277       BOTT-BODENHAUSEN,DE BOUARD,CASSEL+   (CERN)
CAMERINI 66 PR   150 1148      CAMERINI,CLINE,ENGLISH,FISCHBEIN+WISCONSIN
CANTER   66 PRL 17 942         +CHO,ENGLER,FISK,HILL +       (CARNEGIE+BNL)
CARPENTE 66 PR   142  871      CARPENTER,ABASHAN,ABRAMS,FISHER  (ILLINOIS)
CHANG    66 PL   23  702       CHANG,BASSANO,KIKUCHI,DODD+ (SYRACUSE,BNL)

CRIEGEE  66 PRL 17 150         +FOX,FRAUENFELDER,HANSON,MOSCAT+ (ILLINOIS)
FIRESTON 66 PRL 16 556         FIRESTONE,KIM,LACH,SANDWEISS+    (YALE,BNL)
FIRESTON 66 PRL 17 116         FIRESTONE,KIM,LACH,SANDWEISS+.   (YALE,BNL)
FUJII    66 PRL 13 253         FUJII,JOVANOVICH,TURKOT,ZORN (BNL+MARYLAND)
  (FUJII 66 IS THE CORRECTED VALUE GIVEN BY JOVANOVICH+ 66)
GOLDEN   66  BERKELEY 28       R.GOLDEN,F.CRAWFORD,D.STERN             (LRL)
HAWKINS  66 PL 21 238          C J B HAWKINS                          (YALE)
 ALSO    67 PR  156  1444      C J B HAWKINS                          (YALE)

HILL     66 BNL 10608          HILL,ROBINSON,SAKITT,CANTER+ (BNL,CARNEGIE)
JOVANOVI 66 PRL 17 1075        JOVANOVICH,FUJII,TURKOT,ZORN + (BNL+MD+MIT)
KULYUKIN 66  BERKELEY 28       KULYUKINA,MESTVIRISHVILI,NEAGU,PETR+ (JINR)
MEISNER1 66 PRL 16 278         G W MEISNER,B B CRAWFORD,F CRAWFORD   (LRL)
MEISNER2 66 PRL  17  492       G MEISNER,B CRAWFORD,F CRAWFORD       (LRL)
NEFKENS  66 PL 19 706          NEFKENS,ABASHIAN,ABRAMS,CARPENTER+    (ILL)
VERHEY   66 PRL 17 669         VERHEY,NEFKENS,ABASHIAN+// URBANA

BENNETT  67 PRL   19  993      BENNETT,NYGREN,SAAL,STEINBERGER +(COLUMBIA)
BOTT-BOD 67 PL   24B  194      BOTT-BODENHAUSEN,DEBOUARD,CASSEL +   (CERN)
BOTT-BOD 67 PL   24B  438      BOTT-BODENHAUSEN,DEBOUARD,DEKKERS+   (CERN)
    ALSO 66 PL   20  212       BOTT-BODENHAUSEN,DEBOUARD,CASSEL+    (CERN)
    ALSO 66 PL   23  277       BOTT-BODENHAUSEN,DEBOUARD,CASSEL+    (CERN)
CANTER   67 PRL 17 942         CANTER,CHO,ORALLE,ENGLER+    (CARNEGIE,BNL)

CRONIN 1 67 PRL 18 25          +KUNZ,RISK,WHEELER                (PRINCETON)
CRONIN 2 67 PRINC CONF(11/67)  +KUNZ,RISK,WHEELER               (PRINCETON)
DEBOUARD 67 NC   52A  662      DEBOUARD,DEKKERS,JORDAN,MERMOD +      (CERN)
    ALSO 65 PL   15   58       DE BOUARD,DEKKERS,SCHARFF+ (CERN+ORSAY+MPI)
DEVLIN   67 PRL 18 54          DEVLIN,SOLOMON,SHEPARD,BEALL+ (PRINC+MARY.)
DORFAN   67 PRL   19  987      DORFAN,ENSTROM,RAYMOND,SCHWARTZ +(SLAC+LRL)
FELDMAN  67 PR   155  1611     FELDMAN,FRANKEL,HIGHLAND,SLOAN  (U OF PENN)
FIRESTON 67 PRL  18  176       FIRESTONE,KIM,LACH,SANDWEISS,+   (YALE,BNL)
FITCH    67 PR 164  1711       FITCH,ROTH,RUSS,VERNON           (PRINCETON)
GINSBERG 67 PR 162  1570       EDWARD S GINSBERG           (U. MASS BOSTON)

HAWKINS  67 PR   156  1444     C J B HAWKINS                          (YALE)
HILL     67 PRL   19  668      HILL,LUERS,ROBINSON,CANTER+  (BNL,CARNEGIE)
HOPKINS  67 PRL 19  185        HOPKINS,BACON,EISLER                    (BNL)
KADYK    67 PRL 19  597        KADYK,CHAN,DRIJARD,OREN,SHELDON         (LRL)
KULYUKIN 67  PREPRINT          KULYUKINA+MESTVIRISHVILI+NEAGU +       (JINR)
LOWYS    67 PL   24B  75       LOWYS,AUBERT,CHOUNET,PASCAUD+     (EP,ORSAY)
MISCHKE  67 PRL 18  138        MISCHKE,ABASHIAN,ABRAMS+           (ILLINOIS)
NEFKENS  67 PR   157  1233     +ABASHIAN,ABRAMS,CARPENTER,FISHER+      (ILL)
SCHMIDT  67 NEVIS 160(THESIS)  P. SCHMIDT                         (COLUMBIA)
TODOROFF 67  THESIS            JOHN A TODOROFF                    (ILLINOIS)
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Data in parentheses have not been included in our averages.

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ABRAMS   68 PR   176 1603      +ABASHIAN,MISCHKE,NEFKENS,SMITH+ (ILLINOIS)
ARNOLD   68 PL 28B 56          ARNOLD,BUDAGOV,CUNDY,AUBERT+   (CERN+ORSAY)
ARONSCN  68 PRL 20 287         S.H.ARONSON, K.W.CHEN          (PRINCETON)
   ALSO  69 PR  175 1708       S H ARONSON, K W CHEN          (PRINCETON)
BALATZ   68 PL 26B  320        BALATZ,BEREZIN,VISHNEVSKY,GALANINA+(MOSCOW)
BANNER1  68 PRL 21 1103        BANNER,CRONIN,LIV,PILCHER      (PRINCETON)
BANNER2  68 PRL 21 1107        BANNER,CRONIN,LIV,PILCHER      (PRINCETON)
BARTLETT 68 PRL 21 558         BARTLETT,CARNEGIE,FITCH+       (PRINCETON)

BASILE   68 PL 26B  542        BASILE,CRONIN,THEVENET,TURLAY+     (SACLAY)
BASILE1  68 VIENNA ABS. 175    BASILE,CRONIN,THEVENET,TURLAY +    (SACLAY)
BASILE2  68 PL 28B  58         +CRONIN,THEVENET,TURLAY,ZYLBERAJCH+(SACLAY)
BENNETT1 68 PL 27B 244         BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BENNETT2 68 PL 27B 248         BENNETT,NYGREN,STEINBERGER+ (COLUMBIA+CERN)
BLANPIED 68 PRL 21 1650        BLANPIED,LEVIT,ENGELS+    (CASE+HARV+MCGI)
BUDAGOV  68 NC 57A 182         BUDAGOV,BURMEISTER,CUNDY+(CERN,ORSAY,PARIS)
BUDAGOV1 68 PL  28B 215        +CUNDY,MYATT,NEZRICK+       (CERN,ORSAY,EP)

CARNEGIE 68 BAPS  13  16       CARNEGIE,FITCH,KAMAE,ROTH,RUSS+ (PRINCETON)
JAMES    68 NP  88 365         F JAMES, H BRIAND              (PARIS,CERN)
   ALSO  68 PRL 21 257         HELLAND,LONGO,YCUNG        (UCLA,MICHIGAN)
MELHOP   68 PR 172 1613        MELHOP MURTY BOWLES,BURNETT+    (LA JOLLA)
THATCHER 68 PR 174 1674        THATCHER,ABASHIAN,ABRAMS,CARPENTER +  (ILL)

BEILLIER 69 PL  30B 202        BEILLIERE,BOUTANG,LIMON              (EPOL)
BENNETT  69 PL  29B 317        +NYGREN,SAAL,STEINBERGER+        (COLU,BNL)
BOHM     69 NP  89 605         +DARRIULAT,GROSSO,KAFTANOV+          (CERN)
   ALSO  68 PL 27B 321         BOHM,DARRIULAT,GROSSO,KAFTANOV       (CERN)
CENCE    69 PRL 22 1210        CENCE,JONES,PETERSON,STENGER+  (HAWAII,LRL)
CHOLLET  69  CERN 69-7  309    +GAILLARD,JANE,RATCLIFFE,REPELLIN +  (CERN)
EVANS    69 PRL 23 427         EVANS,GOLDEN,MUIR,PEACH+   (EDINBURGH,CERN)
FAISSNER 69 PL  30B 204        +FOETH,STAUDE,TITTEL+      (AACH,CERN,TORI)

GAILLARD 69 NC  59A 453        +GALBRAITH,HUSSRI,JANE+  (CERN,RUTH,AACHEN)
   ALSO  67 PRL 18 20          +KRIENEN,GALBRAITH,HUSSRI+ (CERN+RUTH+AACH)
GOBBI    69 PRL 22 685         +GREEN,HAKEL,MOFFETT,ROSEN,GOZ+ (RCCH+RUTG)
JENSEN   69 PRL 23 615         JENSEN,ARONSON,EHRLICH,FRYBERGER+(EFIN,ILL)
KIRK     69  CERN 69-7  297    +MARX,NYGREN,PEOPLES,STEINBERGER     (CERN)
LITTENBE 69 PRL 22 654         LITTENBERG,FIELD,PICCIONI,MEHLHOP+   (USCD)
LONGO    69 PR 181  1808       M J LONGO,K K YOUNG,J A HELLAND (ANNA,UCLA)
WEBBER   69 UCRL 19266-THESIS  B R WEBBER.                           (LRL)
   ALSO  68 PRL 21 498         WEBBER,SOLMITZ,CRAWFORD,ALSTONGARNJOST(LRL)

                    PAPERS NOT REFERRED TO IN DATA CARDS

ALEXANDE 62 PRL 9 69           G ALEXANDER,S ALMEIDA,F CRAWFORD      (LRL)
JOVANOVI 63 BNL CONF 42        JOVANOVIC,FISCHER,BURRIS +   (BNL+MARYLAND)
STERN    64 PRL 12 459         STERN,BINFORD,LIND,ANDERSON +    (WISC+LRL)
BEHR     65 ARGONNE CONF 59    BEHR,BRISSON,BELLOTTI+   (EP+MILANO+PADOVA)
MESTVIRI 65 JINR P 2449        MESTVIRISHVILI,NYAGU,PETROV,RUSAKOV+ (JINR)
TRILLING 65 UCRL 16473         GEORGE H TRILLING                     (LRL)
TRILLING 65   IS UPDATED FROM  1965 ARGONNE CONF, PAGE 115
RUBBIA   67 PL  24B  531       C.RUBBIA,J.STEINBERGER           (CERN+COL)
  ALSO 1 66 PL  20  207        ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 2 66 PL  21  595        ALFF-STEINBERGER,HEUER,KLEINKNECHT+  (CERN)
  ALSO 3 66 PL  23  167        C.RUBBIA,J.STEINBERGER           (CERN+COL)
CRONIN   68 VIENNA CONF P.281  CRONIN,RAPPORTEURS TALK         (PRINCETON)

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                 14  ETA (549,JPG=0-+)  I=0
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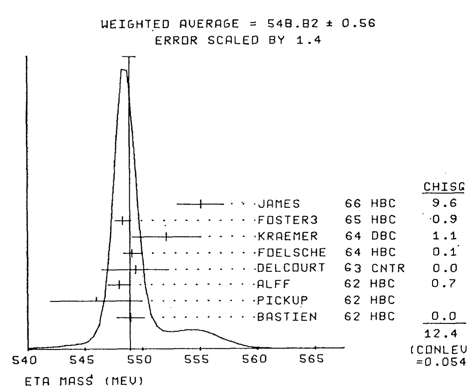
FOR C. BALTAYS REVIEW OF THE ETA MESON, SEE PROC. UNIV.OF PENN.
CONF. ON MESON SPECTROSCOPY (W.A.BENJAMIN, N.Y., 1968)

                 14  ETA MASS  (MEV) .

M       53  549.0      1.2           BASTIEN   62 HBC
M       35  546.0      4.0           PICKUP    62 HBC
M       91  548.0      1.0           ALFF      62 HBC
M           549.3      2.9           DELCOURT  63 CNTR
M      148  549.0      0.7           FOELSCHE  64 HBC
M      325  552.0      3.0           KRAEMER   64 DBC
M           548.2      0.65          FOSTER3   65 HBC                7/66
M      250  555.0      2.0           JAMES     66 HBC                6/66
M
M   AVG     548.82     0.56    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW )
```

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                 14  ETA  WIDTH (MEV)

W       91  (10.0)  OR LESS          ALFF      62 HBC
W      148  (10.0)  OR LESS          FOELSCHE  64 HBC
W       31  (12.0)  OR LESS          JAMES     66 HBC                6/66
W            (4.0)  OR LESS          BALTAY    66 DBC                7/66
W            (.9)   OR LESS          JONES     66 CNTR  .95 CONF.LEVEL  8/67
   ALSO SEE ETA DECAY RATES (BELOW).
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              14  ETA PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     ETA INTO 2GAMMA                                     0+   0
P2     ETA INTO 3PIO                                      134+ 134+ 134
P3     ETA INTO PI+ PI- PIO                               139+ 139+ 134
P4     ETA INTO PI+ PI- GAMMA                             139+ 139+   0
P5     ETA INTO   E+E-PIO        VIOLATES C IN E.M.I.     134+  .5+  .5
P6     ETA INTO E+E-PI+PI-                                139+ 139+  .5+  .5
P7     ETA INTO PIO 2GAMMA                                134+   0+   0
P8     ETA INTO E+E-GAMMA                                  .5+  .5+   0
P9     ETA INTO 2PIO GAMMA       VIOLATES C               134+ 134+   0
P10    ETA INTO PI+PI-PIO GAMMA                           139+ 139+ 134+   0
P11    ETA INTO PI+PI- 2GAMMA                             139+ 139+   0+   0
P12    ETA INTO MU+MU-                                    105+ 105
P13    ETA INTO MU+MU-GAMMA                               105+ 105+   0
P14    ETA INTO MU+MU-PIO                                 105+ 105+ 134

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              14 ETA DECAY RATES

W1     ETA INTO 2GAMMA (UNITS KEV)                         (P1)
W1          (0.93)   (0.2)         BEMPORAD  67 CNTR   PRIMAKOFF EFFECT 11/67

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The above value for $\Gamma_{\gamma\gamma}$ assumes that $\Gamma_{\gamma\gamma}/\Gamma_{total} = 31.4\%$. However, the results of that experiment may be stated more generally than is given in the paper, as

$$\Gamma_{\gamma\gamma} \times \frac{\Gamma_{\gamma\gamma}}{\Gamma_{total}} = 0.380 \pm 0.083 \text{ keV}$$

(private communication from C. Bemporad). Thus our new value of

$$\Gamma_{\gamma\gamma}/\Gamma_{total} = 38.2 \pm 2.1\,\%$$

would give

$$\Gamma_{\gamma\gamma} = 1.00 \pm 0.22 \text{ keV}$$

and

$$\Gamma_{total} = 2.63 \pm 0.64 \text{ keV}.$$

ETA DECAY INTO NEUTRALS

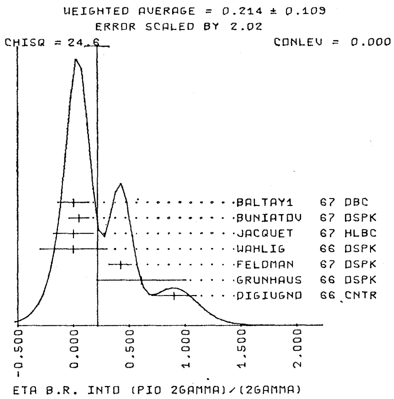
As is well known, there are great inconsistencies among the various experiments which report etas decaying into neutrals. The controversy is over whether the mode $\eta \to \pi^0\gamma\gamma$ is ≈ 0 (as the newer experiments indicate) or $\gtrsim 20\%$ (as the older experiments indicated).

The discrepancies are displayed in the ideogram below, in which all seven relevant experiments have been converted to a common ratio, $\pi^0\gamma\gamma/\gamma\gamma$. Also upper limits, $<x$, have been converted to $0 \pm x$. The confidence level for consistency of all seven is 4×10^{-4}!

At the time of our last edition, the top three experiments (Buniatov, Baltay, and Jacquet) were new and had not borne the tests of time. Hence we were reluctant to discard older experiments, even though the new were inconsistent with the old. We merely warned that the truth must lie somewhere in between.

Data in parentheses have not been included in our averages.

But by now, and after fruitful discussion with Charles Baltay,* we feel that we should consider all seven experiments on an a priori equal basis, and then follow the prescription



of deleting large χ^2 experiments until the confidence level rises to some reasonable value. If we remove the Feldman and DiGiugno experiments, χ^2 decreases from 25 (for all seven) to nearly zero (for the remaining five). Accordingly we have removed these experiments and used the remaining five experiments in our overall fit.

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                    14 ETA   BRANCHING RATIOS

          (P9) IS ASSUMED = 0 IN ALL RATIOS

R1        ETA INTO NEUTRALS/CHARGED                       (P1+P2+P7)/(P3+P4)
R1  N   10   (2.5)     (1.0)           PICKUP    62 HBC
R1  N   53   (3.20)    (1.26)          BASTIEN   62 HBC
R1  N        (2.7)     (0.8)           SHAFER    62 HBC
R1            2.6        .9            BUSCHBECK 63 HBC                      7/66
R1  N  280   (4.5)     (1.0)           JAMES     66 HBC                      6/66
R1  N     THESE EXPERIMENTS HAVE NOT BEEN USED IN COMPUTING THE AVERAGES
R1  N    AS THEY WERE UNABLE TO CLEARLY SEPARATE PARTIAL MODES (3) AND (4) .
R1  N    FROM EACH OTHER.  THE REPORTED VALUES THUS PROBABLY CONTAIN
R1  N    SOME (UNKNOWN) FRACTION OF MODE (4).
R1            2.64      0.23           BALTAY2   67 DBC                     11/67
R1         . . . . . . . . .
R1  AVG       2.64      0.22    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT       2.52      0.15     VALUE FROM CONSTRAINED FIT

R2      ETA INTO 2GAMMA/CHARGED                           (P1)/(P3+P4)
R2            0.99      0.48           CRAWFORD  63 HBC
R2         . . . . . . . . .
R2  FIT       1.35      0.10     VALUE FROM CONSTRAINED FIT

R3        ETA INTO (PIO 2GAMMA)/NEUTRALS                  (P7)/(P1+P2+P7)
R3  S        (0.375)  (0.072)          DIGIUGNO  66 CNTR    ERROR DOUBLED    6/66
R3        THE ERRORS OF DIGIUGNO+ 66 HAVE BEEN INCREASED BY A FACTOR
R3      OF TWO, TO TAKE INTO ACCOUNT POSSIBLE SYSTEMATIC ERRORS, AS
R3      SUGGESTED BY THE AUTHORS.
R3             .27       .10           GRUNHAUS  66 OSPK                     8/67
R3  S        (.244)    (.05)           FELDMAN   67 OSPK                     8/67
R3  S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R3             .028      .044          BUNIATOV  67 OSPK                    11/67
R3           (.06) OR LESS             SHAPIRO   69 OSPK                    9/69*
R3         . . . . . . . . .
R3  AVG       0.067     0.089   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
R3  FIT       0.028     0.047    VALUE FROM CONSTRAINED FIT

R4      ETA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)            (P4)/(P3)
R4            0.14      0.08           FOELSCHE  64 HBC
R4  M   24   (0.73)    (0.25)          PAULI     64 DBC
R4  M     THIS EXPERIMENT HAS NOT BEEN INCLUDED IN THE AVERAGES SINCE
R4  M   IT IS NOT CLEAR THAT THEIR CLASS B EVENTS ARE ACTUALLY FROM ETAS.
R4            0.30      0.06           CRAWFORD  66 HBC                      6/66
R4             .10       .10           KRAEMER   64 DBC                      7/66
R4             .196      .041          FOSTER3   65 HBC                      7/66
R4             .25       .035          LITCHFIEL 67 DBC                      8/67
R4            0.28      0.04           BALTAY2   67 DBC                     11/67
R4         . . . . . . . . .
R4  AVG       0.238     0.023   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R4  FIT       0.236     0.021    VALUE FROM CONSTRAINED FIT
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*See C. Baltay, Proc. of the 1968 Univ. of Penn. Conf. on Meson Spectroscopy (W. A. Benjamin, N. Y., 1968).

```
R5        ETA INTO (3PIO)+ 2/3(PIO 2GAMMA)/ PI+PI-PIO     (P2+2/3P7)/P3
R5            0.83      0.32           CRAWFORD  63 HBC                      7/66
R5            2.0       1.0            FOELSCHE  64 HBC                      7/66
R5            C.90      0.24           FOSTER1   65 HBC                      7/66
R5         . . . . . . . . .
R5  AVG       0.91      0.19    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  FIT       1.42      0.11     VALUE FROM CONSTRAINED FIT

R6      ETA INTO 3PIO/2GAMMA                              (P2)/(P1)
R6           (.90) OR MORE             CHRETIEN  62 PBC
R6            0.88      0.16           BALTAY1   67 DBC                     11/67
R6            1.1       0.2            CENCE     67 OSPK                     1/68
R6  C        (1.06)    (0.31)          STRUGALSK 68 HLBC  CONFERENCE REPORT 11/68
R6         . . . . . . . . .
R6  AVG       0.97      0.12    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R6  FIT       0.821     0.091    VALUE FROM CONSTRAINED FIT

R7      ETA INTO 2GAMMA/(PI+ PI- PO)                      (P1)/(P3)
R7            1.61      0.39           FOSTER1   65 HBC
R7     401    1.72       .25           BAGLIN    69 HLBC                    7/69*
R7         . . . . . . . . .
R7  AVG       1.69      0.21    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R7  FIT       1.66      0.13     VALUE FROM CONSTRAINED FIT

R8        ETA INTO NEUTRAL/(PI+ PI- PIO)                  (P1+P2+P7)/(P3)
R8     280    3.6       0.8            KRAEMER   64 DBC
R8            3.8       1.1            PAULI     64 DBC                      7/66
R8            2.89      0.56           ALFF-STEI 66 HBC                      9/66
R8     244    3.6       0.6            FLATTE2   67 HBC                      1/68
R8         . . . . . . . . .
R8  AVG       3.35      0.35    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  FIT       3.12      0.19     VALUE FROM CONSTRAINED FIT

R9      ETA INTO  (E+E-PIO)/(PI+PI-PIO)  (UNITS 10**-2) (P5)/(P3)
R9           (1.1)  OR LESS            PRICE     65 HBC
R9       0   (0.77) OR LESS            FOSTER2   65 HBC
R9           (.42) OR LESS             BAGLIN1   67 HLBC   .9 CONF.LEVEL     8/67
R9       0   (.16) OR LESS             BILLING   67 HLBC   .9 CONF.LEVEL    11/67

R10       ETA INTO (E+E-PI+PI-)/TOTAL  (UNITS 10**-2)    (P6)/TOTAL
R10          (0.7)OR LESS              RITTENBER 65 HBC                      6/66

R11       ETA INTO (E+E-PI+PI-)/(PI+PI-GAMMA)             (P6)/(P4)
R11      1    0.026     0.026          GROSSMAN  66 HBC                      6/66

R12       ETA INTO 2 GAMMA/NEUTRALS                       (P1)/(P1+P2+P7)
R12 S        (0.416)  (0.044)          DIGIUGNO  66 CNTR    ERRCR DOUBLED    6/66
R12            .44       .07           GRUNHAUS  66 OSPK                     8/67
R12 S        (.579)    (.052)          FELDMAN   67 OSPK                     8/67
R12 S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R12 T        (0.39)    (0.06)          JONES     66 CNTR                     8/67
R12 T   THIS RESULT FROM COMBINING CROSS-SECTIONS FROM TWO DIFFERENT EXPTS.
R12            .59       .033          BUNIATOV  67 OSPK                    11/67
R12        . . . . . . . . .
R12 AVG       0.563     0.058   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
R12 FIT       0.534     0.029    VALUE FROM CONSTRAINED FIT

R13       ETA INTO 3PIO/NEUTRALS                          (P2)/(P1+P2+P7)
R13 S        (0.209)  (0.054)          DIGIUGNO  66 CNTR    ERROR DOUBLED    6/66
R13 R        (.29)     (.10)           GRUNHAUS  66 OSPK                     8/67
R13 S        (.177)    (.035)          FELDMAN   67 OSPK                     8/67
R13 S   SEE THE NOTE ON ETA DECAY INTO NEUTRALS ABOVE.
R13 R        (.41)     (.033)          BUNIATOV  67 OSPK                    11/67
R13 R REDUNDANT INFORMATICN FROM THIS EXPERIMENT
R13        . . . . . . . . .
R13 FIT       0.438     0.040    VALUE FROM CONSTRAINED FIT

R14         ETA INTO PIO (2GAMMA)/2GAMMA                  (P7)/(P1)
R14          (.5)  OR LESS             WAHLIG    66 SPRK   .9 CONF LEVL      7/66
R14           0.0       0.14           BALTAY1   67 DBC                     11/67
R14 P        (0.05)    (0.04)          BONAMY    67 SPRK  PRELIMINARY RESULT 11/67
R14 C        (0.30)    (0.22)          STRUGALSK 68 HLBC  CCNFERENCE REPORT 11/68
R14        . . . . . . . . .
R14 FIT       0.052     0.090    VALUE FROM CONSTRAINED FIT

R15         ETA INTO (E+E-PIO)/TOTAL (UNITS 10**-2)       (P5)/TOTAL
R15          (0.7)OR LESS              RITTENBER 65 HBC                      6/66
R15          (0.084)OR LESS            BAZIN     68 DBC  .9 CONF LEVL        6/68

R16       ETA INTO 2GAMMA/(3PIO + PIO 2GAMMA)             (P1)/(P2+P7)
R16           0.80       .25           BACCI     63 CNTR                     7/66
R16        . . . . . . . . .
R16 FIT       1.15      0.14     VALUE FROM CONSTRAINED FIT

R17       ETA INTO (PI+PI-PIO GAMMA)/(PI+PI-PIO)          (P10)/(P3)
R17          (.07) OR LESS             FLATTE    67 HBC                      8/67
R17          (.009)OR LESS             PRICE     67 HBC                      8/67
R17          (.016)OR LESS             BALTAY2   67 DBC    .95 CONF LEVL    11/67
R17          (0.017)OR LESS            ARNOLD    68 HLBC    .9 CONF LEVEL    9/68

R18       ETA INTO (PI+PI- 2GAMMA)/(PI+PI-PIO)            (P11)/(P3)
R18          (.009)OR LESS             PRICE     67 HBC                      8/67
R18          (.016)OR LESS             BALTAY2   67 DBC    .95 CONF LEVL    11/67

R19     ETA INTO 3PIO/(PI+ PI- PIO)                       (P2)/(P3)
R19           1.3        .4            BAGLIN2   67 HLBC                     8/67
R19           1.47      0.20      0.17 BULLOCK   68 HLBC                     9/68
R19    199    1.50       .15       .29 BAGLIN    69 HLBC                    7/69*
R19        . . . . . . . . .
R19 AVG       1.46      0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R19 FIT       1.37      0.12     VALUE FROM CONSTRAINED FIT

R20       ETA INTO 2GAMMA/((3PIO)+2/3(PIO 2GAMMA))        (P1)/(P2+2/3P7)
R20           1.10      0.5            MULLER    63 DBC                      7/66
R20        . . . . . . . . .
R20 FIT       1.17      0.12     VALUE FROM CONSTRAINED FIT

R21     ETA INTO NEUTRALS/TOTAL                           (P1+P2+P7)/TOTAL
R21            .79       .08           BUNIATOV  67 OSPK                    11/67
R21        . . . . . . . . .
R21 FIT       0.716     0.012    VALUE FROM CONSTRAINED FIT

R22     ETA INTO (PIZRO 2GAMMA)/TOTAL                     (P7)/TOTAL
R22          (.12) OR LESS             JACQUET   67 HLBC   .9 CONF LEVL     11/67
R22        . . . . . . . . .
R22 FIT       0.020     0.034    VALUE FROM CONSTRAINED FIT

R23     ETA INTO MU+MU-/TOTAL     (UNITS 10**-5)          (P12)/TOTAL
R23      0   (2.)   OR LESS            WEHMANN   68 OSPK   .95 CONF.LEVEL    4/68

R24     ETA INTO MU+MU-PIO/TOTAL  (UNITS 10**-4)          (P14)/TOTAL
R24          (5.)   OR LESS            WEHMANN   68 OSPK                     4/68

R25     ETA INTO MU+MU-/2GAMMA    (UNITS 10**-5)          P(12)/(P1)
R25           5.9       2.2            HYAMS     69 OSPK                    7/69*
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4	P 7
P 1	.382+-.021				
P 2	-.182	.314+-.027			
P 3	-.167	.196	.230+-.010		
P 4	-.132	-.010	.200	.054+-.005	
P 7	-.483	-.693	-.377	-.127	.02C+-.028

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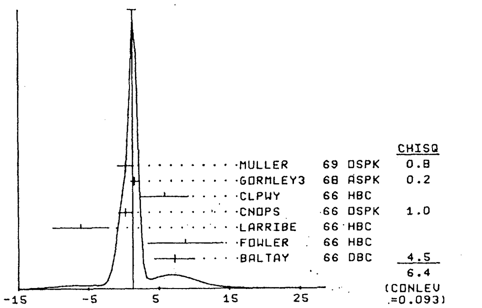
14 ETA C-NONCONSERVING DECAY PARAMETER

A DECAY ASYMMETRY PARAMETER FOR PI+ PI- PIO (UNITS 10**-2)

A	1351	7.2	2.8	BALTAY	66 DBC	8/66
A	355	8.7	5.3	FOWLER	66 HBC	8/66
A	705	-6.1	4.0	LARRIBE	66 HBC	8/67
A	10665	0.3	1.0	CNOPS	66 OSPK	8/67
A	1300	5.8	3.4	CLPWY	66 HBC	8/66
A	3680C	1.5	.5	GORMLEY3	68 ASPK	6/68
A	10709	.3	1.1	MULLER	69 OSPK	9/69*
A		. . . . .	. . . . .			
A	AVG	1.29	0.59	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5) (SEE IDEOGRAM BELOW)		

WEIGHTED AVERAGE = 1.29 ± 0.59
ERROR SCALED BY 1.5



ETA INTO PI+PI-PIO ASYMMETRY PARAMETER

B DECAY ASYMMETRY PARAMETER FOR PI+ PI- GAMMA (UNITS 10**-2)

B	33	-2.	17.	CRAWFORD	66 HBC	11/66
B	1620	1.5	2.5	BOWEN	67 OSPK	8/67
B	N ABOVE EXPERIMENT IS SENSITIVE ONLY TO UPPER .4 OF GAMMA-RAY SPECTRUM					
B		-4.	8.	LITCHFIEL	67 DBC	8/67
B	6710	2.4	1.4	GORMLEY2	68 ASPK	6/68
B	1620	1.5	2.5	MULLER	69 OSPK	9/69*
B		. . . . .	. . . .			
B	AVG	1.9	1.1	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)		

H. Yuta and S. Okubo [PRL 21, 781 (1968)] have pointed out that an asymmetry in the decay $\eta \to \pi^+\pi^-\pi^0$ of about 2% need not imply a breakdown of C invariance, since an asymmetry of this amount could be caused by an interference between the η and the 3π background. Gormley et al. [PRL 22, 108 (1969)], however, believe that this effect can account for only ≤ 0.23% in their experiment (above).

REFERENCES
14 ETA(549,JPG=0-+)I=0

PEVSNER 61 PRL 7 421 PEVSNER,KRAEMER,NUSSBAUM,RICHARDSON + (JHU)

ALFF 62 PRL 9 322 ALFF,BERLEY,COLLEY,BRUGGER + (CCL+RUTGERS)
BASTIEN 62 PRL 8 114 BASTIEN,BERGE,DAHL,FERRO-LUZZI + (LRL)
CHRETIEN 62 PRL 9 127 CHRETIEN+ (BRAND+BROWN+HARVARD+MIT+PADOVA)
PICKUP 62 PRL 8 329 E PICKUP,ROBINSON,SALANT (NRC+CAN+BNL)
SHAFER 62 CERN CONF 307 J SHAFER,FERRO-LUZZI,MURRAY + (UC+LRL)

BACCI 63 PRL 11 37 BACCI,PENSO,SALVINI + (ROME U+CNEN FRASCA)
BUSCHBEC 63 SIENA CONF 1 166 BUSCHBECK-CZAPP,COOPER + (VIENNA+CERN+AMS)
CRAWFORD 63 PRL 10 546 F S CRAWFORD,LLOYD,FOWLER (LRL+DUKE)
AND PRL 16 907 F S CRAWFORD,L LLOYD,E FOWLER (LRL+DUKE)
DELCOURT 63 PL 7 215 DELCOURT,LEFRANCOIS,PEREZ Y JORBA+ (ORSAY)
MULLER 63 SIENA CONF 99 MULLER,PAULI + (LPCHE+SACLAY IF+ROME+INFN)

FOELSCHE 64 PR 134 B 1138 H W FOELSCHE,H L KRAYBILL (YALE)
KRAEMER 64 PR 136 B 496 KRAEMER,MADANSKY,FIELDS + (JHU+NW U+WOOD)
PAULI 64 PL 13 351 E PAULI,A MULLER (LPCHE+SACLAY)

FOSTER1 65 PR 138 B 652 FOSTER,PETERS,MEER,LOEFFLER + (WISC+PURDUE)
FOSTER2 65 ATHENS FOSTER,GOOD,MEER (WISCONSIN)
FOSTER3 65 THESIS M.C.FOSTER (WISCONSIN)
PRICE 65 PRL 15 123 L.R.PRICE,F.S.CRAWFORD (LRL)
RITTENBE 65 PRL 15 556 RITTENBERG,KALBFLEISCH (LRL+BNL)

ALFF-STE 66 PR 145 1072 ALFF-STEINBERGER,BERLEY+ (COLUMBIA+RUTGERS)
BALTAY 66 PRL 16 1224 +FRANZINI,KIM,KIRSCH+(COLUMBIA+STONY BROOK)
CRAWFORD 66 PRL 16 333 F.S.CRAWFORD,L.R.PRICE (LRL)
DIGIUGNO 66 PRL 16 767 DIGIUGNO,GIORGI,SILVESTRI+ (NAP+TRST+FRASC)
GROSSMAN 66 PR 146 993 R GROSSMAN,L PRICE,F CRAWFORD (LRL)
GRUNHAUS 66 THESIS J.GRUNHAUS (COLUMBIA)
JAMES 66 PR 142 896 F E JAMES,H L KRAYBILL (YALE+BNL)
JONES 66 PL 23 597 JONES,BINNIE,DUANE,HORSEY,MASON,+(ICL+RUTH)
WAHLIG 66 PRL 17 221 WAHLIG,SHIBATA,MANNELLI (MIT+PISA)

BAGLIN1 67 PL 24B 637 BAGLIN,BEZAGUET,DEGRANGE,+ (E.POLY+UC)
BAGLIN2 67 BAPS 12 567 BAGLIN,BEZAGUET,DEGRANGE,+ (E.POLY+UC)
BALTAY1 67 PRL 19 1495 BALTAY,FRANZINI,KIM,NEWMAN+ (COLUM+BRAND)
BALTAY2 67 PRL 19 1498 BALTAY,FRANZINI,KIM,NEWMAN+(COLUM+STONY BK)
BEMPORAD 67 PL 25B 380 BEMPORAD,BRACCINI,FOA,LUBELSMEY+(PISA,BONN)
AND PRIVATE COMMUNICATION
BILLING 67 PL 25B 435 BILLIG,BULLOCK,ESTEN,GOVAN,+ (UCL,OXF)
BONAMY 67 HEIDELBERG CONF. BONAMY,SONDEREGGER (SACLAY)
BUNIATOV 67 PL 25B 560 BUNIATOV,ZAVATTINI,DEINET,+ (CERN,KARLS)
CENCE 67 PRL 19 1393 CENCE,PETERSON,STENGER,CHIU+ (HAWAII+LRL)
FELDMAN 67 PRL 18 868 FELDMAN,FRATI,GLEESON,HALPERN,+ (PENN)
FLATTE 67 PRL 18 976 S.M.FLATTE (LRL)
FLATTE2 67 PR 163 1441 S.M.FLATTE AND C.G.WOHL (LRL)
JACQUET 67 PL 25B 574 JACQUET,NGUYEN-KHAC,BAGLIN+(EC.POLY,BERGEN)
LITCHFIE 67 PL 24B 486 LITCHFIELD,RANGAN,SEGAR,SMITH+(RUTH+SACLAY)
PRICE 67 PRL 18 1207 L.R.PRICE,F.S.CRAWFORD (LRL)

ARNOLD 68 PL 27B 466 +PATY,BAGLIN,BINGHAM+ (STRB+MADR+EPOL+BERK)
BAZIN 68 PRL 20 895 BAZIN,GOSHAW,ZACHER,+ (PRINCETON,QUEENS)
BULLOCK 68 PL 27B 402 +ESTEN,FLEMING,GOVAN,HENDERSON,OWEN+ (LOUC)
STRUGALS 68 VIENNA ABS. 112 STRUGALSKI,CHUVILO,IVANOVSKAJA,+ (DUBNA)
WEHMANN 68 PRL 20 748 WEHMANN,ENGELS,+(HARV+CASE+SLAC+COR+MCGILL)

BAGLIN 69 PL 29B 445 BAGLIN,BEZAGUET,+ (EPOL,BERK,MADR,STRB)
HYAMS 69 PL 29B 128 HYAMS,KOCH,POTTER,VON LINDERN,+ (CERN,MPIM)
SHAPIRO 69 NEVIS 174(THESIS) STEPHEN SHAPIRO (COLU)

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

BASTIEN 62 PRL 8 114 BASTIEN,BERGE,DAHL,FERRO-LUZZI,MILLER+(LRL)
CARMONY 62 PRL 8 117 D CARMONY,A ROSENFELD,VAN DE WALLE (LRL)
ROSENFEL 62 PRL 8 293 A ROSENFELD,D CARMONY,VAN DE WALLE (LRL)

REFERENCES ON ETA ASYMMETRY PARAMETERS

BALTAY 66 PRL 16 1224 BALTAY,FRANZINI,KIM,KIRSCH+(COLUM+STONY BK)
CNOPS 66 PL 22 546 CNOPS,FINOCCHIARS,LASSALLE,+(CERN+ZUR+SACL)
CRAWFORD 66 PRL 16 333 F.S.CRAWFORD,L.R.PRICE (LRL)
FOWLER 66 BAPS 11 380 E.C.FOWLER (DUKE)
LARRIBE 66 PL 23 600 LARRIBE,LEVEQUE,MULLER,PAULI,+ (SACL+RUTH)
CLPWY 66 PR 149 1044 COLUMBIA,LRL,PURDUE,WISCONSIN,YALE

BOWEN 67 PL 24B 206 BOWEN,CNOPS ,FINOCCHIARO,+ (CERN+ZUR+SACL)
LITCHFIE 67 PL 24B 486 LITCHFIELD,RANGAN,SEGAR,SMITH+(RUTH+SACLAY)
GORMLEY2 68 PRL 21 399 GORMLEY,HYMAN,LEE,NASH,PEOPLES+ (COLU+BNL)
GORMLEY3 68 PRL 21 402 GORMLEY,HYMAN,LEE,NASH,PEOPLES+ (COLU+BNL)
MULLER 69 THESIS ARMAND MULLER (STRB)

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16 PROTON (938,J=1/2) I=1/2

16 PROTON MASS (MEV)

M	938.256	0.005	COHEN	65 RVUE	7/66

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16 PROTON LIFETIME (UNITS 10**26 YR)

T	OVER 10**20 YRS		GOLDHABER	54 TH 232 FISS.MODE INDEPEN		
T	OVER 2.0 * 10**23 YRS		FLEROV	57 TH 232 FISS.MODE INDEPEN.		
T	OVER	1.5	BACKENSTO	60 CNTR		
T	OVER	60.0	KROPP	65 CNTR		6/66
T	KROPP AND BACKENSTOSS SENSITIVE TO PARTICULAR DECAY MODES OF PROT					
T	OVER	200.0	GURR	67 CNTR DEP. ON DECAY MODE		6/68

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16 PROTON MAGNET. MOMENT(E/2MP).

MM	2.792763	0.000030	COHEN	65 RVUE	7/66

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16 PROTON ELECTRIC DIPOLE MOMENT (IN UNITS OF 10**-23 E CM)
NONZERO VALUE IMPLIES VIOLATION OF T AND P IN EM INTERACTION

EDM	10**9	700.	900.	HARRISON	69 MBR	10/69*

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REFERENCES
16 PROTON (938,J=1/2) I=1/2

GOLDHABER 54 PR 96 1157 FNOTE2 M GOLDHABER,F REINES+ (LOS ALAMOS,BNL)
FLEROV 57 SOV PHYS DOK 3 78 FLEROV,KLOCHKOV,SKOBKIN,TERENTEV (USSR)
BACKENST 60 NC 16 749 BACKENSTOSS,FRAUENFELDER,HYAMS + (CERN)
COHEN 65 RMP 37 537 E R COHEN, J W M DUMOND (NAASC+CALTECH)
KROPP 65 PR 137 B 740 W R KROPP,F REINES (CASE INST TECHNOLOGY)
GURR 67 PR 158 1321 GURR,KROPP,REINES,MEYER (CASE,JOHANNESBURG)
HARRISON 69 PRL 22 1263 HARRISON,SANDARS,WRIGHT (CLARENDON OXFORD)

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Data in parentheses have not been included in our averages.

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                 17  NEUTRON (939,J=1/2)  I=1/2

                 17  NEUTRON-PROTON MASS DIF.(MEV)
D               1.2939   0.0004         BONDELID  60 CNTR
D               1.2933   0.0001         SALGO     64 CNTR
D               . . . . . . . . . .
D   AVG         1.2933   0.0001  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
D   FIT       1.2923   0.0001     VALUE FROM CONSTRAINED FIT

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                 17  NEUTRON MAGNETIC MOMENT (MAGNETONS,938.2 MEV)
MM           -1.913148 0.000066         COHEN     56 RVUE                 7/66

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          17  NEUTRON ELECTRIC DIPOLE MOMENT  ( IN UNITS OF 10**-23 E CM)
              TEST OF C VIOLATION IN THE EM INTERACTION

EDM            (5.)   OR LESS           BAIRD     69 MBR.                10/69*

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                 17  NEUTRON LIFETIME (UNITS 10**3 SEC)

         THE MEASUREMENT OF THE NEUTRON LIFETIME BY SOSNOVSKII 59 HAS
         BEEN DISCARDED SINCE 1.  IT DISAGREES WITH THE BETTER AND MORE
         RECENT RESULT OF CHRISTENSEN 67.  2.  THE VALUE OF GA/GV DE-
         RIVED FROM THE NEW VALUE OF THE LIFETIME AGREES WELL WITH THE
         GA/GV VALUE OBTAINED FROM THE FREE NEUTRON DATA.

T              (1.012)  (0.021)         SOSNOVSKI 59 PILE     SEE NOTE E   7/68
    E  ERROR CHANGED BECAUSE ERROR IN CROSS SECTION FOR NEUTRON ABSORPTION
    E  IN GOLD HAS BEEN REDUCED
T               0.932    0.014          CHRISTENS 67 PILE                  3/68

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                 17  BETA DECAY COUPLING CONSTANTS

AV       GA/GV  (SEE TEXT FOR SIGN CONVENTION)
AV  B       (-1.18)   (0.02)            BHALLA    66 RVUE                 11/67
AV           -1.250    0.044            CONFORTO  67 RVUE  SEE NOTE C BELOW
AV           -1.23     0.01             CHRISTENS 67 CNTR  SEE NOTE D BELOW  11/68
AV  B    THIS VALUE NOT USED SINCE CORRESPONDING  LIFETIME HAS BEEN DISCARDE
AV  C       CONFORTO VALUE COMBINES ALL FREE NEUTRON DECAY DATA
AV  D       CHRISTENSON MEASUREMENT NOT SENSITIVE TO SIGN OF GA/GV
AV          . . . . . . . . . .
AV  AVG     -1.2310    0.0098  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

F        PHASE ANGLE OF GA RELATIVE TO GV  (DEGREES)
    C                      VALUE DERIVED FROM FREE NEUTRON DECAY ONLY
F   C      (176.1)    (6.4)             CONFORTO  67 RVUE                 11/68
F   S      (178.7)    (1.3)             EROZOLIMS 68 CNTR    POLAR. NETRON 10/69*
F   S    ONLY STATISTICAL ERROR QUOTED

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                              REFERENCES
                              17 NEUTRON (939,J=1/2) I=1/2

COHEN    56 PR 104 283         V W COHEN, CORNGOLD, RAMSEY   (BNL+HARVARD)
SOSNOVSK 59 JETP  9  717       SOSNOVSKII,SPIVAK,PROKOFEV +    (IAE MOSCOW)
BONDELID 60 PR  120  887       BONDELID,BUTLER,KENNEDY + (USNRL+CATH UNIV)
SALGO    64 NP   53  457       R SALGO, STAUB, WINKLER, ZAMBONI    (ZURICH)

BHALLA   66 PL 19  691         C P BHALLA                        (ALABAMA)
CHRISTEN 67 PL 26B 11          +NIELSEN,BAHNSEN,BROWN,RUSTAD(RISO-DENMARK)
CONFORTO 67 ACTA PHYS ACAD
   HUNGARICA 22  15 G. CONFORTO                                     (CERN)
EROZOLIM 68 PL 27B 557         EROZOLIMSKY,BONDARENKO  +  (KURC IN MOSCOW)
BAIRD    69 PR  179  1285      +MILLER,DRESS,RAMSEY              (ORNL,HARV)

                     PAPERS NOT REFERRED TO IN DATA CARDS

JACKSCN  57 PR 106 517         JACKSON,TREIMAN,WYLD              (PRINCETON)
COHEN    65 RMP 37 537         E R COHEN,DUMOND         (NAASC+CAL INST TECH)
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                 18  LAMBDA (1115,JP=1/2+)  I=0

                 18  LAMBDA  MASS (MEV)

M   N  SINCE OUR FINAL VALUES FOR THE SIGMA AND LAMBDA MASSES COME FROM
M   N  DOING AN OVERALL FIT TO ALL MEASURED MASSES AND MASS DIFFERENCES,
M   N  WE HAVE USED THE UNCORRELATED MEASUREMENTS FROM SCHMIDT 65 RATHER
M   N  THAN THE ONES COMING FROM THE OVERALL FIT REPORTED IN THAT PAPER.
M   N  SINCE THERE SEEMS TO BE NO CONVINCING ARGUMENT AS TO WHY ONE SHOULD
M   N  IGNORE DATA USING RANGE MEASUREMENTS, WE HAVE INCLUDED HERE VALUES
M   N  DEPENDING ON PROTON AND PION RANGES.

M          1115.44     0.12           BHOWMIK   63 RVUE +  SEE NOTE L BELOW
M   L  ABOVE LAMBDA MASS HAS BEEN RAISED 35 KEV TO ACCOUNT FOR 46 KEV
M   L  INCREASE IN PROTON MASS AND 11 KEV DECREASE IN CHARGED PION MASS.
M   S  635(1115.86)   (0.09)          BALTAY    65 HBC    ERROR IS STATIS.   6/66
M      488 1115.63     0.07           SCHMIDT   65 HBC  SEE NOTE N           6/68
M   S 1147(1115.74)   (0.04)          CHIEN     66 HBC      6.9 PBAR P       9/67
M   S  972(1115.69)   (0.05)          CHIEN     66 HBC      6.9 PBAR PANTIL  9/67
M          1115.6      0.4            LONDON    66 HBC                       6/66
M         (1116.0)    (0.2)           BADIER    67 HBC    2.4 PBAR P,LLBAR   8/67
M      195 1115.39     0.12           MAYEUR    67 EMUL                     11/67
M   S      ERROR PURELY STATISTICAL
M          . . . . . . . . . .
M   AVG    1115.544    0.075   AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.4)
M   FIT    1115.60     0.08      VALUE FROM CONSTRAINED FIT                  6/68
                       (SEE IDEOGRAM BELOW )

                 18  LAMDA - ANTILAMBDA MASS DIFFERENCE (MEV)
DM              0.05     0.06         CHIEN     66 HBC      6.9 PBAR P       9/67
DM              0.29     0.15         BADIER    67 HBC    2.4 PBAR P         8/67
DM         . . . . . . . . . .
DM  AVG         0.083    0.083   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)

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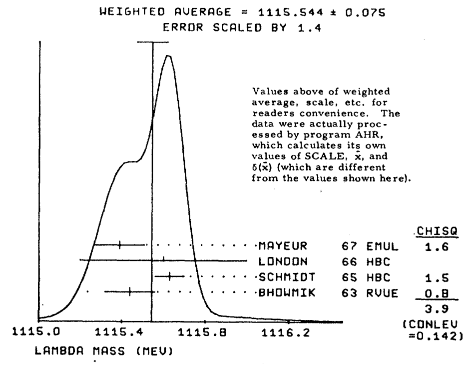


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                 18  LAMBDA LIFETIME (UNITS 10**-10)

T       188    2.63     0.21     0.21  BOLDT     58 CC
T       825    2.72     0.16     0.16  CRAWFORD  59 HBC
T       140    2.72     0.29     0.27  BOWEN     60 CC
T       186    2.60     0.28     0.20  CHANG     62 HBC
T       799    2.69     0.11     0.11  HUMPHREY  62 HBC
T     -2239    2.36     0.06     0.06  BLOCK     63 HEBC
T       706    2.76     0.20           CHRETIEN  63 HLBC
T       794    2.59     0.09           HUBBARD   64 HBC
T      2260    2.31     0.10           KREISLER  64 OSPK
T      1378    2.59     0.07           SCHWARTZ  64 HBC
T       635    2.51     0.16           BALTAY    65 HBC                      6/66
T      2534    2.6      0.1            HILL      65 OSPK
T       916    2.35     0.09           BURAN     66 HLBC                     6/66
T   S  1147   (2.50)   (0.14)          CHIEN     66 HBC      6.9 PBAR P      9/67
T   S   972   (2.70)   (0.20)          CHIEN     66 HBC      6.9 PBAR P,ANTI 9/67
T      2213    2.452    0.056   0.054  ENGELMANN 66 HBC                      9/66
T       585    2.68     0.13    0.11   AUERBACH  67 OSPK                     8/67
T              2.44     0.15           BADIER    67 HBC    2.4 PBAR P        6/68
T              2.55     0.15           BADIER    67 HBC    2.4 PBAR P,ANTIL  6/68
T   G  8342   (2.535)  (0.035)         GRIMM     68 HBC                      6/68
T     2600     2.47     0.08           HEPP      68 HBC                      8/68
T   S        ERROR PURELY STATISTICAL
T   G        TEMPORARELY NOT AVERAGED SINCE ERRORS ARE ONLY STATISTICAL     11/68
T            . . . . . . . . . .
T   AVG        2.514    0.030    0.029  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                        (SEE IDEOGRAM BELOW )
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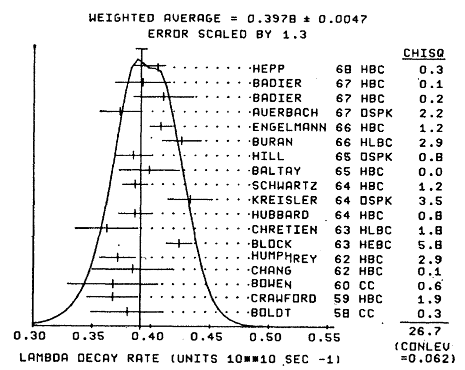


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                 18  LIFETIME DIFFERENCE,(LAMBDA-ANTILAMDA)/AVERAGE

DT              0.044    0.085          BADIER    67 HBC     2.4 PBAR P      8/67
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                 18  LAMBDA MAGNETIC MOMENT (MAGNETONS,938.26 MEV)

MM             -1.5      0.5            COOL      62 OSPK
MM              0.0      0.6            KERNAN    63 CC
MM      8553   -1.39     0.72           ANDERSON  64 HBC
MM       151   -0.5      0.28           CHARRIERE 65 EMUL
MM             -0.77     0.27           HILL      65 OSPK                    9/66
MM          . . . . . . . . . .
MM  AVG        -0.73     0.20    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                         (SEE IDEOGRAM BELOW )

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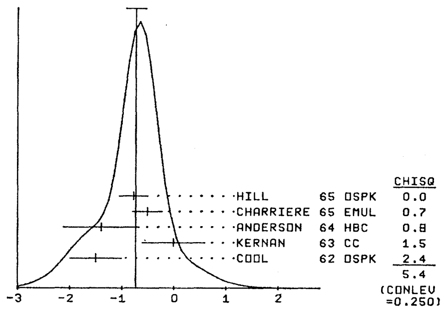
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = -0.73 ± 0.20
ERROR SCALED BY 1.2



18 LAMBDA PARTIAL DECAY MODES

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                                                        DECAY MASSES
P1     LAMBDA INTO PROTON PI-                           938+ 139
P2     LAMBDA INTO NEUTRON PIO                          939+ 134
P3     LAMBDA INTO PROTON MU- NEUTRINO                  938+ 105+   0
P4     LAMBDA INTO PROTON E- NEUTRINO                   938+  .5+   0
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18 LAMBDA BRANCHING RATIOS

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R1     LAMBDA INTO (P PI-)/((P PI-)+(N PIO))              (P1)/(P1+P2)
R1            0.627    0.031          CRAWFORD  59 HBC
R1            0.65     0.05           COLUMBIA  60 HBC
R1  U        (0.685)  (0.017)         ANDERSON  62 HBC
R1     903    0.643    0.016          HUMPHREY  62 HBC
R1         • • • • • • • • •
R1  AVG       0.640    0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT       0.653    0.013    VALUE FROM CONSTRAINED FIT

R2     LAMBDA INTO (N PIO)/((P PI-)+(N PIO))              (P2)/(P1+P2)
R2            0.23     0.09           EISLER    57 HLBC
R2            0.43     0.14           CRAWFORD  59 HBC
R2            0.28     0.08           BAGLIN    60 HLBC
R2            0.35     0.05           BROWN     63 HLBC
R2      75    0.291    0.034          CHRETIEN  63 HLBC
R2         • • • • • • • • •
R2  AVG       0.304    0.025   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT       0.347    0.013    VALUE FROM CONSTRAINED FIT

R3     LAMBDA INTO (P E- NEU)/TOTAL      (UNITS  10**-3)  (P4)/(P1+P2)
R3  O   15   (2.0)     (0.5)          HUMPHREY  61 RVUE
R3  O    8   (2.9)     (1.5)    (1.2) AUBERT    62 FBC
R3     150    0.82      0.12     0.13 ELY       63 FBC
R3      20    1.55      0.34          LIND      64 HBC
R3     102    0.78      0.12          BAGLIN    64 FBC
R3     143    0.80      0.08          MALONEY   69 HBC                       10/69*
R3         • • • • • • • • •
R3  AVG       0.821    0.073   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                               (SEE IDEOGRAM BELOW )
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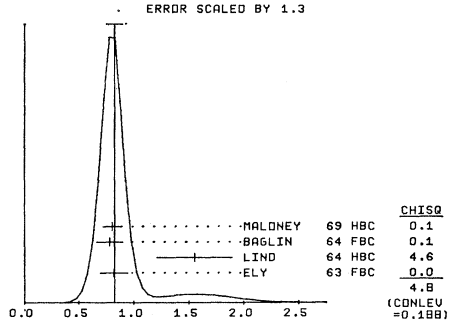
WEIGHTED AVERAGE = 0.821 ± 0.073
ERROR SCALED BY 1.3

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R4     LAMBDA INTO (P MU- NEU)/TOTAL  (UNITS  10**-4)  (P3)/(P1+P2)
R4       1   (0.2)  OR GREATER        GOOD      62 HBC
R4       1   (1.0)  OR LESS           ALSTON    63 HBC
R4       2   (1.0)  OR LESS           KERNAN    64 FBC
R4      BETWEEN 1.3 AND 6.0           LIND      64 HBC
R4       3    1.3       0.7           LIND      64 RVUE                          7/66
R4       2    1.5       1.2           RONNE     64 FBC
R4         • • • • • • • • •
R4  AVG       1.35      0.60   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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18 LAMBDA DECAY PARAMETERS

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A-     ALPHA LAMBDA- (LAMBDA INTO PI- PROTON)
A-    1156    0.62      0.07          CRONIN    63 CNTR   LAMBDA FROM PI-P  8/67
A-           (0.663)   (0.022)        BERGE     66 RVUE  INCLUDES ABOVE     9/66
A-   10130    0.645     0.017         OVERSETH  67 OSPK   LAMBDA FROM PI-P  8/67
A-  M 2529   (0.747)   (0.086)        MERRILL   68 HBC  REPL BY DAUBER 68   6/68
A-    3520    0.67      0.06          DAUBER    69 HBC  FROM XI DECAY       6/68
A-         • • • • • • • • •
A-  AVG       0.645     0.016  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AO     ALPHAO /ALPHA- FOR LAMBDA (L INTO PIO N/L INTO PI- P)
AO            1.10      0.27          CORK      60 CNTR

F-     PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGRESS)
F-    1156    13.0      17.0          CRONIN    63 OSPK   LAMBDA FROM PI-P 11/67
F-   10130    -8.0       6.0          OVERSETH  67 OSPK   LAMBDA FROM PI-P 11/67
F-    7377   (-9.2)     (5.2)         CLELAND   67 OSPK   REP BY ANDERSSON 11/68
F-            -6.7       4.5          ANDERSSON 68 OSPK                    11/68
F-         • • • • • • • • •
F-  AVG       -6.3       3.5   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AL        ASYMMETRY PARAMETER IN ELECTRON - LAMBDASPIN CORRELATION
AL            0.06      0.19          BARLOW    65 OSPK                         7/66

AV     GA/GV FOR LAMBDA BETA DECAY (SEE TEXT FOR SIGN CONVENTION)
AV  C   22  (-1.03)                   LIND      64 HBC                          6/68
AV  C  102 ABS VALUE GREATER THAN 0.6 BAGLIN    65 HLBC                         6/68
AV  C      BETW 0. AND -1.1           BARLOW    65 OSPK                         6/68
AV  C  102 ABS VALUE GREATER THAN 0.7 ELY       65 HLBC   95 PCT CONF LEV       6/68
AV           -1.14      0.23     0.33 CONFORTO  65 RVUE                        11/67
AV  C          EXPTS INCLUDED IN CONFORTO 65, RVUE                             6/68
AV      30  (-0.23)    (0.20)   (0.33) CHU      68 OSPK   PRELIMINARY          11/68
AV M   148  -0.72       0.14     0.19 MALONEY   69 HBC                         10/69*
AV M                         MALONEY 69 MEASURES THE ABSOLUTE VALUE OF A/V
AV         • • • • • • • • •
AV  AVG      -0.83      0.18   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
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REFERENCES
18 LAMBDA (1115,JP=1/2+) I=0


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EISLER   57 NC      5 1700       EISLER,PLANO,SAMIOS,SCHWARTZ +  (COLUM+BNL)
BOLDT    58 PRL     1  148       E BOLDT,D O CALDWELL,Y PAL               (MIT)
CRAWFORD 59 PRL     2  266       CRAWFORD,CRESTI,DOUGLASS,GOOD +          (LRL)

BAGLIN   60 NC     18 1043       BAGLIN,BLOCH,BRISSON,HENNESSY +  (PARIS-EP)
BOWEN    60 PR    119 2030       BOWEN,HARDY,REYNOLDS,SUN +      (PRINCETON)
CORK     60 PR    120 1000       CORK,KERTH,WENZEL,CRONIN,COOL  (LRL+PR+BNL)
COLUMBIA 60 ROCH CONF 726        M SCHWARTZ +                     (COLUMBIA)
HUMPHREY 61 PRL     6  478       HUMPHREY,KIRZ,ROSENFELD,RHEE +  (LRL+SYRAC)

ANDERSON 62 CERN CONF 832        ANDERSON,CRAWFORD,GOLDEN,LLOYD +        (LRL)
AUBERT   62 NC     25  479       AUBERT,BRISSON,HENNESSY,SIX +    (PARIS-EP)
CHANG    62 THESIS DUKE          CHUEN CHUEN CHANG                      (DUKE)
COOL     62 PR    127 2223       COOL,HILL,MARSHALL +        (BNL+MIT+NYU+ANL)
GOOD     62 PRL     9  518       M L GOOD,V G LIND                 (WISCONSIN)
HUMPHREY 62 PR    127 1305       W E HUMPHREY,R R ROSS                   (LRL)

ALSTON   63 UCRL 10926           ALSTON,KIRZ,NEUFELD,SOLMITZ,WOHLMUT    (LRL)
BHOWMIK  63 NC     28 1494       B BHOWMIK,D P GOYAL                   (DELHI)
BLOCK    63 PR    130  766       BLOCK,GESSAROLI,RATTI,KIKUCHI +  (NW+BLGNA)
BROWN    63 PR    130  769       BROWN,KADYK,TRILLING,ROE +   (LRL+MICHIGAN)
CHRETIEN 63 PR    131  2208      CHRETIEN,CROUCH+  (BRAND+BROWN+HARVARD+MIT)
CRONIN   63 PR    129 1795       J W CRONIN,O E OVERSETH           (PRINCETON)
ELY      63 PR    131  868       ELY,GIDAL,KALMUS,OSWALD,POWELL +        (LRL)
KERNAN   63 PR    129  870       KERNAN,NOVEY,WARSHAW,WATTENBERG   (ANL+ILL)

ANDERSON 64 PRL    13  167       J A ANDERSON,F S CRAWFORD               (LRL)
BAGLIN   64 NC     35  977       BAGLIN,BINGHAM+ (EP+CERN+UC LOND+RHEL+BERG)
HUBBARD  64 PR    135 B 183      HUBBARD,BERGE,KALBFLEISCH,SHAFER +      (LRL)
KERNAN   64 PR    133 B 1271     KERNAN,POWELL,SANDLER +  (LRL+UN-COLL-LOND)
KREISLER 64 PR 136 B 1074        M N KREISLER,C OVERSETH,J CRONIN   (PRINCE)
LIND     64 PR    135 B 1483     LIND,BINFORD,GOOD,STERN           (WISCONSIN)
RONNE    64 PL     11   357      RONNE+    (CERN+EP+UCOL-LONDON+UNIV.BERGEN)
SCHWARTZ 64 UCRL 11360 THESIS JOSEPH ADAM SCHWARTZ                      (LRL)

BAGLIN   65 NC 35 977            BAGLIN +     (EP,CERN,UC LONDON,RUTH,BERGEN)
BALTAY   65 PR 140 B 1027        BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BARLOW   65 PL  18  64           J BARLOW,BLAIR,CONFORTO+  (CERN+RUTH+PENNA)
CHARRIER 65 PL   15    66        CHARRIERE,GIBSON+       (EPUL+BRIST+CERN+MPI)
   ALSO     NC  46A  205         CHARRIERE,GIBSON +   (EPUL,BRIST,CERN, MPI)
CONFORTO 65 EC INT HERZEGNOVI G CONFORTO                               (CERN)
ELY      65 PR 137 B1302         ELY,GIDAL,KALMUS,POWELL +   (LRL,UC LONDON)
HILL     65 PRL  15     85       D A HILL,K K LI,JENKINS              (BNL+MIT)
SCHMIDT  65 PR 140 B 1328        P SCHMIDT                          (COLUMBIA)

BERGE    66  BERKELEY 46         BERGE,CABIBBO                          (RVUE)
BURAN    66 PL 20 318            BURAN,EIVINDSON,SKJEGGESTAD,TOFTE +  (OSLO)
CHIEN    66 PR  152  1171        +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
ENGELMAN 66 NC 45A  1038         ENGELMANN,FILTHUTH,ALEXANDER+(HEIDBG+WEIZM)
LONDON   66 PR 143 1034          LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL+SYRACUS)

AUERBACH 67 NC  47A  19          AUERBACH,BOWEN,DOBBS,LANDE,MANN+  (U OF PA)
BADIER   67 PL 25B 152           +BONNET,BRIANDET,SADOULET       (EP (PARIS))
MAYEUR   67 U.LIBR.BRUX.BUL32 C.MAYEUR,E.TOMPA,J.WICKENS (UL.BRUX+UC.LON)
CLELAND  67 PL 26B 45            CLELAND,BIENLEIN,CONFORTO+  (CERN,GVA,LUND)
OVERSETH 67 PRL  19  391         O E OVERSETH, R F ROTH (MICHIGAN+PRINCETON)

ANDERSSO 68 VIENNA ABS. 270      ANDERSSON,BIENLEIN,CLELAND +(CERN,GVA,LUND)
CHU      68 VIENNA POSTDEADLN CHU,PHILLIPS, + (ARGONNE,CHICAGO,OHIO,WASH)
GRIMM    68 NC 54A 187           H.-J.GRIMM                       (HEIDELBERG)
HEPP     68 ZPHYS 214 71         V.HEPP,H. SCHLEICH               (HEIDELBERG)
MERRILL  68 PR 167 1202          MERRILL,SHAFER                          (LRL)
DAUBER   69 PR  179 1262         +BERGE,HUBBARD,MERRILL,MILLER           (LRL)
MALONEY  69 PRL 23 425           MALONEY,SECHI-ZORN           (UNIV MARYLAND)
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PAPERS NOT REFERRED TO IN DATA CARDS

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ARMENTER 62 CERN CONF 236        ARMENTEROS+(CERN+EP+LONDON+BIRM+CEN-SACLAY)
BALTAY   62 CERN CONF 233        BALTAY,FOWLER,SANDWEISS,CULWICK+ (YALE+BNL)
BERGE    63 THESIS (BERKELEY) J PETER BERGE                            (LRL)
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

Σ^+

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            19  SIGMA+   (1189,JP=1/2+)  I=1

            19  SIGMA+ MASS (MEV)

M   N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M      144 1189.38     0.15              BARKAS    63 EMUL +  SEE NOTE S BELOW
M       58 1189.48     0.22              BHOWMIK   64 EMUL +  SEE NOTE S BELOW
M   S  ABOVE SIGMA+ MASSES HAVE BEEN RAISED 30  KEV TO ACCOUNT FOR 46 KEV
M   S  INCREASE IN PROTON MASS AND 21 KEV DECREASE IN PION MASS
M  .  4205 1189.68     0.10              SCHMIDT   65 HBC  SEE NOTE N            6/68
M          1189.16     0.12              HYMAN     67 HEBC                       6/68
M          . . . . . . . . . .
M   AVG    1189.45     0.13    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)
M   FIT    1189.40     0.19     VALUE FROM CONSTRAINED FIT                       6/68
                       (SEE IDEOGRAM BELOW )
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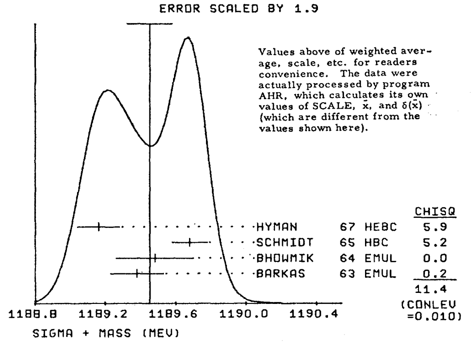
WEIGHTED AVERAGE = 1189.45 ± 0.13
ERROR SCALED BY 1.9



Note on $\Sigma^{\pm}$ Lifetime Errors

When combining lifetimes, we first convert mean lives τ to decay rates Γ, since for small numbers of events the Γ are more nearly Gaussian distributed. However, in checking input data it is useful to bear in mind the theoretical minimum statistical error $\delta_{min}(\tau)$ in the mean life itself. This is

$$\delta_{min} = \frac{\tau}{\sqrt{N_{eff}}} ,$$

$$N_{eff} = N\left[1 - x^2 \frac{e^x}{(e^x - 1)^2}\right], \qquad (1)$$

where N = number of decays seen over the time interval Δt and $x = \Delta t/\tau$.

Consider the Σ^- mean life of CHANG 66: $1.67 \pm 0.026 \times 10^{-10}$ sec., based on 3267 events. The Σ^- were produced by K^- stopping in a hydrogen bubble chamber. Since stopping Σ^- were not included in the analysis, the decays were observed for only 2.7×10^{-10} sec. Then $x = 1.62$, and N_{eff} is about N/5. Equation (1) then gives $\delta_{min} = 0.065$, or 2.5 times larger than that quoted by CHANG 66.

In order to evaluate the actual error we have redone the χ^2 minimization described by CHANG 66, using his published data, and find $\delta(\tau)$ to be 0.075.

We find his Σ^+ lifetime error also to be too small, and have redone his analysis to give ±0.032.

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                  19  SIGMA+ LIFETIME (UNITS 10**-10)

T                                             GLASER     58 RVUE
T       127     0.98      0.16      0.12   PUSCHEL    60 EMUL
T        41     0.82      0.34      0.20   EVANS      60 EMUL
T       117     0.85      0.14      0.11   FREDEN     60 EMUL
T        54     0.80      0.10      0.067  KAPLON     60 EMUL
T        23     0.76      0.22      0.14   CHIESA     61 EMUL
T        49     0.75      0.13      0.09   BERTHELOT  61 HLBC
T       140     0.82      0.10      0.08   BARKAS     61 EMUL
T       192     0.749     0.056     0.052  GRARD      62 HBC
T       456     0.765     0.04      0.04   HUMPHREY   62 HBC
T       203     0.84      0.12      0.08   BHOWMIK    64 EMUL
T       181     0.84      0.09             BALTAY     65 HBC                   6/66
T       900     0.76      0.03             CARAYAN    65 HBC                   6/66
T   C  1300     0.83      0.032            CHANG      66 HBC                   6/66
T   C       CHANG ERROR 0.018 RAISED BY US .SEE NOTE PRECEDING SIGMA- LIST.  11/69*
T    S  125    (0.86)    (0.15)            CHIEN      66 HBC  +  6.9 PBAR P    9/67
T    S  117    (1.10)    (0.24)            CHIEN      66 HBC  -  6.9 PBAR P,ANTI 9/67
T       381     0.80      0.07             COOK       66 OSPK                  7/66
T     10664     0.803     0.008            BARLOUTAU  69 HBC   K-P .4-1.2 GEV/C 11/69*
T    S      ERROR PURELY STATISTICAL
T           . . . . . . . . . .
T    AVG        0.8020    0.0072   0.0071  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  19  SIGMA+ MAGNETIC MOMENT (MAGNETONS,938.26 MEV)
MM      381     1.5       1.1              COOK       66 OSPK                  7/66
MM       52     3.5       1.5              KOTELCHUC  67 EMUL  K-P AT 1.15BEV/C 8/67
MM       51     3.0       1.2              SULLIVAN   67 EMUL  PHOTOPRODUCTION  8/67
MM       69     3.5       1.2              COMBE      68 EMUL                 10/68
MM    29333     2.1       1.0              MAST       68 HBC   K-P AT .4 GEV/C  6/68
MM          . . . . . . . . . .
MM   AVG        2.57      0.52    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                  19  SIGMA+ PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      SIGMA + INTO PROTON PIO                          938+ 134
P2      SIGMA + INTO NEUTRON PI+                         939+ 139
P3      SIGMA + INTO NEUTRON PI+ GAMMA                   939+ 139+  0
P4      SIGMA + INTO LAMBDA E+ NEU                      1115+  .5+  0
P5      SIGMA + INTO PROTON GAMMA                        938+   0
P6      SIGMA + INTO NEUTRON MU+ NEUTRINO                939+ 105+  0
P7      SIGMA + INTO NEUTRON E+ NEUTRINO                 939+  .5+  0
P8      SIGMA + INTO PROTON E+ E-                        938+  .5+ .5

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                  19  SIGMA+  BRANCHING RATIOS

R1      SIGMA+  INTO (NEUTRON PI+)/(NUCLEON PI)           (P2)/(P1+P2)
R1      308    0.490     0.024           HUMPHREY  62 HBC
R1      534    0.46      0.02            CHANG     66 HBC                      6/66
R1     1331    0.488     0.010           BARLOUTAU 69 HBC   K-P .4-1.2 GEV/C 11/69*
R1          . . . . . . . . . .
R1   AVG       0.4833    0.0084  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2      SIGMA+ INTO (NEUT PI+ GAM)/(PI+N)  (UNITS 10**-3) (P3)/(P2)
R2      ABOUT  1.8                       BAZIN2    65 HBC   PI+ LT 116 MEV/C  8/67
R2       29    0.27      0.05            ANG       69 HBC   PI+ LT 110 MEV/C 11/68

R3       SIGMA+ INTO (LAMBDA E+ NEU)/TOTAL (UNIT 10**-5) (P4)/TOTAL
R3   W    4    (3.3)     (1.7)           WILLIS    64 HBC   STOP. K-          9/66
R3   W                EVENTS FROM THIS EXPERIMENT,INCLUDED IN EISELE1 69     11/69*
R3        6     2.0       0.8            BARASH    67 HBC   STOP K-           8/67
R3        5     1.6       0.7            BALTAY    69 HBC   STOP K-          11/69*
R3       10     2.9       1.0            EISELE1   69 HBC   STOP K-          10/69*
R3          . . . . . . . . . .
R3   AVG        2.02      0.47   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      SIGMA+  INTO (P GAMMA)/(P PIO)  (UNITS 10**-2)   (P5)/(P1)
R4        1    (0.68) OR LESS            CARRARA   64 HBC
R4       24     0.37      0.08           BAZIN     65 HBC
R4        4    (0.17)                    QUARENI   65 EMUL                    6/66
R4       45     0.21      0.03           ANG       69 HBC    STOP K-         10/69*
R4       31     0.276     0.051          GERSHWIN  69 HBC                    10/69*
R4          . . . . . . . . . .
R4   AVG        0.240     0.035  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                       (SEE IDEOGRAM BELOW )

R5      SIGMA+  INTO (N E+ NEU)/(N PI+)  (UNITS 10**-5)  (P7)/(P2)
R5   E    0   (16220)EFFECTIVE DENOM.  COURANT   64 HBC    SEE NOTE E       11/67
R5   E    0    (2720)EFFECTIVE DENOM.  MURPHY    64 HBC    SEE NOTE E       11/67
R5   E    1    (9690)EFFECTIVE DENOM.  NAUENBERG 64 HBC    SEE NOTE E        6/68
R5   E           EFFECTIVE DENOM.  TAKEN FROM EISELE 67                     11/67
R5        0   (32406)EFFECTIVE DENOM.  BIERMAN   68 HBC                      6/68
R5   U    0   (80400)EFFECTIVE DENOM.  EISELE2   69 HBC                      6/68
R5   U    1   (30000)EFFECTIVE DENOM.  NORTON    69 HBC                     11/69*
R6   U           EFFECTIVE DENOM. CALCULATED BY US
R5        2   (0.7) OR LESS C.L=.90   OUR AVERAGE USING ALL ABOVE           11/69*

R6      SIGMA+  INTO (N MU+ NEU)/(PI+N)   (UNITS 10**-5) (P6)/(P2)
R6        1     (120)ANALYSED EVENTS   GALTIERI  62 EMUL   NO RATIO QUOTED  11/67
R6   E    0   (10150)EFFECTIVE DENOM.  COURANT   64 HBC    SEE NOTE E       11/67
R6   E    0    (1710)EFFECTIVE DENOM.  NAUENBERG 64 HBC    SEE NOTE E       11/67
R6   U    2   (62000)EFFECTIVE DENOM.  EISELE2   69 HBC                      6/68
R6        0   (33800)EFFECTIVE DENOM.  BAGGETT   69 HBC                     11/68
R6        3   (1.1) OR LESS  C.L=.90   OUR AVERAGE USING ALL ABOVE          11/69*
R6               SEE NOTES ACCOMPANYING R5
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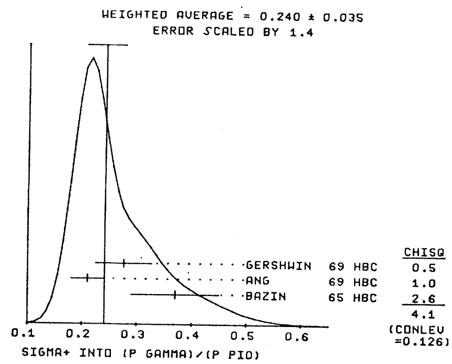
Data in parentheses have not been included in our averages.

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R7      SIGMA+ INTO LEPTONS / SIGMA- INTO LEPTONS
R7  N     5   (0.03)                  OUR AVERAGE                        10/69*
R7  N      AVERAGE OF ALL DATA IN R5 AND R6 UP TO BIERMAN 68.             6/68
R7        0   (0.034)OR LESS          BAGGETT   67 HBC                    6/68
R7        1   (0.08) OR LESS          NORTON    69 HBC                   10/69*

R8      SIGMA+ INTO (PROTON E+ E-)/  TOTAL (UNIT 10**-6) (P8)/TOTAL
R8            (7.0)  OR LESS          ANG       69 HBC     STOP K-       10/69*
R8   A   ANG 69 FOUND 3 E+E- EVENTS IN AGREEMENT WITH GAMMA CONVERSION OF
R8   A   PROTON GAMMA DECAY -LIMIT GIVEN HERE IS FOR NEUTRAL CURRENT

R9      SIGMA+ INTO (N MU+ NU)/ SIGMA- INTO (N MU- NU)
R9        2  0.06      0.045    0.03  EISELE2   69 HBC  +-   STOP K-     10/69*

R10     SIGMA+ INTO (N E+ NU)/ SIGMA- INTO (N E- NU)
R10       0  (0.03)  OR LESS          EISELE2   69 HBC  +-   STOP K-     10/69*
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19 SIGMA+ DECAY PARAMETERS

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A+0      ALPHA+/ALPHAO FOR SIGMA+ (SIG+ TO PI+ N)/(SIG+ TO PIO P)
A+0            +0.04     0.11          CORK      60 CNTR     SIG+ FROM PI+P
A+0           (+0.20)   (0.24)         TRIPP     62 HBC   +  REPLAC.BY BANGER
A+0 0 3500    (-.014)   (0.052)        BANGERTER 66 HBC   +  SIG+ FROM K-P     9/66
A+0 0 2600    (-.047)   (.07)          BERLEY    66 HBC   +  SIG+ FROM K-P     9/66
A+0 0         OLD RESULTS,HAVE BEEN REPLACED . SEE BELOW -

A+       ALPHA SIGMA++(SIG+ TO PI+ N)
A+   35000     0.069     0.017         BANGERTER 69 HBC      K-P AT 400 MEV/C 11/69*
A+             0.062     0.046         BERLEY    69 HBC      K-P AT 400 MEV/C 11/69*
A+          • • • • • • • • • •
A+   AVG       0.068     0.016   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

A0      ALPHA SIGMAO (SIG+ INTO PIO PROTON)
A0             -0.80     0.16          BEALL     62 CNTR
A0            (-0.90)   (0.25)         TRIPP     62 HBC      REPLAC. BY BANGE
A0   0 5200   (-0.986)  (0.072)        BANGERTER 66 HBC      K-P TO SIG+ PI-    7/66
A0   32000    -0.999     0.022         BANGERTER 69 HBC                        10/69*
A0          • • • • • • • • • •
A0   AVG      -0.995     0.022   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

F+       PHI+ ANGLE (SIG+ INTO N PI)  SIN(PHI)/COS(PHI)=BETA/GAMMA  (DEGREE)
F+   0  370 (180.)     (30.)           BERLEY    66 HBC   +  NEUTRON RESCATT.  9/66
F+    C       184.      24.            BERLEY    69 HBC      K-P AT 400 MEV/C 11/69*
F+    C                          CHANGED FROM 176 TO 184 TO AGREE WITH SIGN CON
F+      560  143.       29.            BANGERT1  69 HBC                        10/69*
F+          • • • • • • • • • •
F+   AVG     167.3      20.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

AG       ALPHA SIGMAG (SIG+ INTO PROTON GAMMA)
AG       61   -1.03      0.52      0.42 GERSHWIN  69 HBC     K-P TO SIG PI     11/69*

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REFERENCES
19 SIGMA + (1189,JP=1/2+) I=1


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EVANS    60 NC 15 873          BRIST+BRUSS+IAS-U.COL-DUBLIN+LON+MILAN+PAD
FREDEN   60 NC 16 611          S FREDEN,H KORNBLUM,R WHITE              (LRL)
KAPLON   60 ANP 9 139          M KAPLON,A MELISSINOS,YAMANOUCHI     (ROCHES)
CORK     60 PR 120 1000        CORK,KERTH,WENZEL,CRONIN,COOL (LRL+PRI+BNL)
PUSCHEL  60 NP 20 254          W PUSCHEL                  (MAX PLANCK INST)

BARKAS   61 PR 124 1209        BARKAS,DYER,MASON,NICHOLS,SMITH          (LRL)
BERTHELO 61 NC 21 693          BERTHELOT,DAUDIN,GOUSSU +      (SACLAY+ORSAY)
CHIESA   61 NC 19 1171         CHIESA,QUASSIATI,RINAUDO         (INFN-TURIN)

BEALL    62 PRL 8 75           BEALL,CORK,KEEFE,MURPHY,WENZEL           (LRL)
GRARD    62 PR 127 607         F GRARD,G A SMITH                        (LRL)
GALTIERI 62 PRL 9 26           GALTIERI,BARKAS,HECKMAN,PATRICK,SMITH (LRL)
HUMPHREY 62 PR 127 1305        W E HUMPHREY,R R ROSS                    (LRL)
TRIPP    62 PRL 9 66           R D TRIPP,M B WATSON,M FERRO-LUZZI       (LRL)

BARKAS   63 PRL 11 26          W H BARKAS,J N DYER,H H HECKMANN         (LRL)
   ALSO  61 UCRL 9450          JOHN DYER (THESIS, BERKELEY)             (LRL)

BHOWMIK  64 NP 53 22           B BHOWMIK,P JAIN,P MATHUR,LAKSHMI    (DELHI)
CARRARA  64 PL 12 72           CARRARA,CRESTI,GRIGOLETTO,PERUZZO+ (PADOVA)
COURANT  64 PR 136 B 1791      COURANT,FILTHUTH+ (CERN+HEIDLB+MD+NRL +BNL)
MURPHY   64 PR 134 B 188       C THORNTON MURPHY                 (WISCONSIN)
NAUENBER 64 PRL 12 679         NAUENBERG,MARATECK,BLUMENFELD+ (COL+RUT+PR)
WILLIS   64 PRL 13 291         WILLIS,COURANT,ENGELMAN+ (BNL+CERN+HEID+MD)

BALTAY   65 PR 140 B 1027      BALTAY,SANDWEISS,CULWICK,KOPP +  (YALE+BNL)
BAZIN    65 PRL 14 154         BAZIN,BLUMENFELD,NAUENBERG + (PRINCE+COLUM)
BAZIN2   65 PR 140  B1358         BAZIN,PLANO,SCHMIDT+ (PRINCE,RUTG,COLUM)
CARAYAN  65 PR 138 B 433       CARAYANNOPOULOS,TAUTFEST,WILLMANN  (PURDUE)
QUARENI  65 NC 40 A 928        QUARENI,CARTACCI +         (BOL+FIR+GEN+PARMA)
SCHMIDT  65 PR 140 B 1328      P SCHMIDT                          (COLUMBIA)

BANGERTE 66 PRL  17  495       BANGERTER,GALTIERI,BERGE,MURRAY+      (LRL)
BERLEY   66 PRL 17 1071        +HERZBACH,KOFLER,YAMAMOTO + (BNL+MASS+YALE)
CHANG    66 PR  151  1081      CHUNG YUN CHANG                    (COLUMBIA)
   ALSO  65 NEVIS 145  THESIS CHUNG YUN CHANG                     (COLUMBIA)
CHIEN  . 66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
COOK     66 PRL  17  223       V COOK,EWART,MASEK,ORR,PLATNER (WASHINGTON)

BARASH   67 PRL 19  181        BARASH,DAY,GLASSER,KEHOE,KNOP +  (MARYLAND)
EISELE   67 ZPHYS 205 409      +ENGELMANN,FILTHUTH,FOLISH,HEPP+ (HEIDELB.)
HYMAN    67 PL 25 B 376        +LOKEN,PEWITT,MCKENZIE,KEYES+(ARG+CARN+NWU)
KOTELCHU 67 PRL 18 1166        KOTELCHUCK,GOZA,SULLIVAN,ROSS (VANDERBILT)
SULLIVAN 67 PRL 18 1163        SULLIVAN,MCINTURFF,KOTELCHUCH (VANDERBILT)
   ALSO  64 PRL 13 246         A D MCINTURFF,C E ROOS         (VANDERBILT)

BAGGETT  68 VIENNA ABS. 374    BAGGETT,KEHOE                      (MARYLAND)
   ALSO  67 PRL 19 1458        BAGGETT,DAY,GLASSER,KEHOE,KNOP+  (MARYLAND)
   ALSO  68 PRIVATE COMMUNICATION FROM N. BAGGETT                 (MARYLAND)
BIERMAN  68 PRL 20 1459        BIERMAN,KOUNOSU,NAUENBERG +     (PRINCETON)
COMBE    68 NC 57A 54          CERN-BRISTOL-LAUSANNE-MUNICH-ROME-COLLAOR
MAST     68 PRL 20 1312        MAST,GERSHWIN,ALSTON-GARNJOST +        (LRL)

ANG      69 ZPHYS 228 151      +EBENHOH,EISELE,ENGELMANN,FILTHUTH+  (HEID)
BAGGETT  69 MDDP-TR-973        N V BAGGETT (THESIS)                    (MD)
BALTAY   69 PRL 22 615         BALTAY,FRANZINI,NEWMAN,NORTON+  (COLU,STON)
BANGERTE 69 UCRL-19244         ROGER ODELL BANGERTER (THESIS)         (LRL)
BANGERT1 69 PR NOV 25          BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)
BARLOUTA 69 NP TO BE PUBLIS.   BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
BERLEY   69 PR TO BE PUBLISH.  +KOFLER, YAMAMOTO,WILLIS +
EISELE1  69 ZPHYS 221 1        +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+    (HEID)
EISELE2  69 ZPHYS 221 401      +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+    (HEID)
GERSHWIN 69 UCRL-19246         LAWRENCE KENNETH GERSHWIN (THESIS)     (LRL)
NORTON   69 NEVIS 175 (THESIS) HERBERT NORTON                     (COLUMBIA)
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QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

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TRIPP    62 PRL 8 175          R TRIPP,M WATSON,M FERRO-LUZZI         (LRL)
ALFF     63 SIENA CONF 1 205   ALFF,NAUENBERG,KIRSCH,BERLEY+(COLU+RUT+BNL)
   ALSO  65 PR 137 B 1105      ALFF,GELFAND,BRUGGER,BERLEY+(COLUM+RUT+BNL)
COURANT  63 SIENA CONF 1 73    COURANT,FILTHUTH,BURNSTEIN,DAY+ (CERN+MARY)
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PAPERS NOT REFERRED TO IN DATA CARDS

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GLASER   58 CERN CONF 270      GLASER,GOOD,MORRISON                (MICH+LRL)
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20 SIGMA- (1198,JP=1/2+) I=1

20 SIGMA- MASS (MEV)

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M    N SEE NOTE PRECEDING LAMBDA MASS LISTINGS

M      3000 1197.47     0.11          SCHMIDT   65 HBC  SEE NOTE N          6/68
M           • • • • • • • • • •
M    FIT    1197.32     0.11     VALUE FROM CONSTRAINED FIT                 6/68
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20 SIGMA- MASS DIFFER.(-)-(+)(MEV)

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D        87    8.25     0.40          BARKAS    63 EMUL  -
D      2500    8.25     0.25          DOSCH     65 HBC
D           • • • • • • • • • •
D    AVG       8.25     0.21     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D    FIT       7.92     0.18      VALUE FROM CONSTRAINED FIT                6/68
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20 (SIGMA-) - (LAMBDA) MASS DIFFERENCE (MEV)

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DL   N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL            81.70     0.19          BURNSTEIN 64 HBC                      9/66
DL       85   81.80     0.24          SCHMIDT   65 HBC  SEE NOTE N          6/68
DL     2279   81.64     0.09          HEPP      68 HBC                      8/68
DL          • • • • • • • • • •
DL   AVG      81.666    0.077    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
DL   FIT      81.72     0.09      VALUE FROM CONSTRAINED FIT                6/68
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20 SIGMA- LIFETIME (UNITS 10**-10)

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T             1.67      0.40     0.28 BROWN     58 HLBC
T             1.89      0.33     0.25 EISLER    58 HLBC
T        45   1.35      0.32     0.17 CHIESA    61 EMUL
T        41   1.75      0.39     0.30 BARKAS    61 EMUL
T      1208   1.58      0.06     0.06 HUMPHREY  62 HBC     STOP. K-
T   C  3267   1.666     0.075         CHANG     66 HBC     STOP. K-         6/66
T   C      CHANG ERROR 0.026 RAISED BY US .SEE NOTE PRECEDING SIGMA- LIST.  11/69*
T    S   61  (2.08)    (0.22)         CHIEN     66 HBC  -  6.9 PBAR P       9/67
T    S   64  (1.46)    (0.31)         CHIEN     66 HBC  +  6.9 PBAR P,ANTI  9/67
T    S     ERROR PURELY STATISTICAL
T       506   1.38      0.07          WHITESIDE 68 HBC     STOP. K-         6/68
T     10253   1.472     0.016         BARLOUTAU 69 HBC     K-P .4-1.2 GEV/C 11/69*
T           • • • • • • • • • •
T    AVG      1.490     0.031    0.030   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                          (SEE IDEOGRAM BELOW )
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20 SIGMA- PARTIAL DECAY MODES

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                                                            DECAY MASSES
P1      SIGMA - INTO  NEUTRON PI-                          939+ 139
P2      SIGMA - INTO  NEUTRON PI- GAMMA                    939+ 139+   0
P3      SIGMA - INTO  NEUTRON MU- NEUTRINO                 939+ 105+   0
P4      SIGMA - INTO  NEUTRON E- NEUTRINO                  939+  .5+   0
P5      SIGMA - INTO  LAMBDA E- NEUTRINO                  1115+  .5+   0
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20 SIGMA- BRANCHING RATIOS

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R1      SIGMA - INTO (N MU- NEU)/(N PI-) (UNITS 10**-3)  (P3)/(P1)
R1      22    0.66      0.15          COURANT   64 HBC.
R1      11    0.56      0.20          BAZIN     65 HBC      FROM STOP. K-    6/66
R1      56    0.43      0.09          BAGGETT   69 HBC     STOP. K-         10/69*
R1      72    0.43      0.06          ANG 1     69 HBC     STOP K-          10/69*
R1      13    0.38      0.13          NORTON    69 HBC     STOP. K-         10/69*
R1          • • • • • • • • • •
R1   AVG      0.450     0.043    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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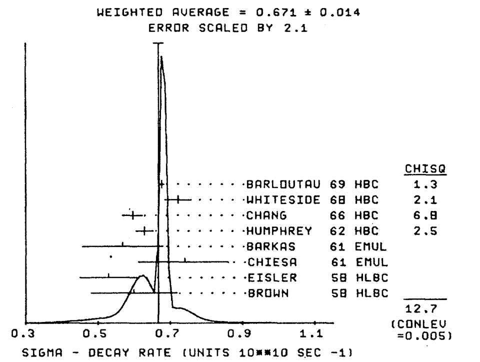
See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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R2      SIGMA - INTO (N E- NEU)/(N PI-)  (UNITS 10**-3)  (P4)/(P1)
R2        9    1.0       0.4        0.3  MURPHY    64 HLBC
R2       16    1.37      0.34            NAUENBERG 64 HBC
R2       16    1.15      0.4             MILLER    64 FBC
R2       31    1.4       0.3             COURANT   64 HBC
R2      180    1.11      0.09            BIERMAN   68 HBC                    6/68
R2            (1.11)    (0.15)           SECHIZOR  68 HBC   PRELIMINARY     10/68
R2      331    1.02      0.08            ANG 1     69 HBC   STOP K-         10/69*
R2       58    0.97      0.13            NORTON    69 HBC                   10/69*
R2           . . . . . . . . . .
R2  AVG        1.063     0.052   AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.0)

R3      SIGMA - INTO (LAMBDA E- NEU)/(N PI-) (UNITS 10**-4)(P5)/(P1)
R3       11    0.75      0.28            COURANT   64 HBC   STOP. K-
R3       35    0.64      0.12            BARASH    67 HBC   STOP K-          8/67
R3       31    0.69      0.12            EISELE1   69 HBC   STOP K-         10/69*
R3       31    0.52      0.09            BALTAY    69 HBC   STOP K-          4/69*
R3           . . . . . . . . . .
R3  AVG        0.604     0.060   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4      SIGMA - INTO (N PI- GAMMA)/(NPI-) (UNITS 10**-3)(P2)/(P1)
R4      ABOUT  1.1                       BAZIN     65 HBC   PI- LT 166 MEV/C  8/67
R4       23     .10       .02            ANG       69 HBC   P(PI-) LT 110    10/69*

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                    20 SIGMA- DECAY PARAMETERS

A-      ALPHA SIGMA-
A-           (-0.16)   (0.21)            TRIPP     62 HBC   REPL.BY BANGERTE
A-  0 6500  (-0.010)  (0.043)            BANGERTER 66 HBC   K-P TO SIG- PI+   7/66
A-  0          OLD RESULTS,HAVE BEEN REPLACED . SEE BELOW -
A-  0 6068  (-0.104)  (0.04)             BERLEY    67 HBC   K-P TO SIG- PI+  11/67
A-   51000   -0.071    0.012             BANGERTER 69 HBC                   10/69*
A-           -0.134    0.034             BERLEY    69 HBC   K-P AT 400 MEV/C 11/69*
A-           . . . . . . . . . .
A-  AVG      -0.078    0.020   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)

F-      PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F-  0 1006 (+22.)     (30.)              BERLEY    67 HBC   K-P TO SIG- PI+  11/67
F-    1385   14.       19.               BANGERT1  69 HBC                   10/69*
F-   C      + 5.       23.               BERLEY    69 HBC   NEUTRON RESCATT. 11/69*
F-   C                          CHANGED FROM -5  TO +5  TO AGREE WITH SIGN CON
F-           . . . . . . . . . .
F-  AVG        10.3      14.6    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AV      GV/GA FOR SIGMA TO LAMBDA BETA DECAY (SEE TEXT FOR SIGN CONVENTION)
AV      PREDICTED TO BE ZERO BY CONSERVED VECTOR CURRENT THEORY
AV   B  45    0.31      0.30             BARASH    67 HBC                   11/67
AV   B                BARASH 67 MEASURED ABSOLUTE VALUE
AV   S  81   +0.22      0.28             EISELE1   69 HBC                   10/68
AV   S  51    0.7       0.4              BALTAY    69 HBC   USING SIG+-      4/69*
AV   S                SIGN CHANGED TO AGREE WITH OUR CONVENTION
AV           . . . . . . . . . .
AV  AVG       0.35      0.18     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

AV1     GA/GV FOR SIGMA TO NEUTRON BETA DECAY (SEE TEXT FOR SIGN CONVENTIO)
AV1     57   (0.05)    (0.23)    (0.32) GERSHWIN  68 HBC  REPLACED BY GER.69   6/68
AV1  C  49    0.23      0.16            COLLERAIN 69 HBC  NEUTRON SCATTER.    10/69*
AV1  C  33    0.37      0.26      0.19  EISELE2   69 HBC  NEUTRON SCATTER.    10/69*
AV1  C COLLERAINE AND EISELE MEASURE THE ABSOLUTE VALUE OF GA/GV             11/68
AV1     61   +0.19      0.20      0.17  GERSHWIN  69 HBC  POLARIZED SIGMAS    10/69*
AV1          . . . . . . . . . .
AV1 AVG       0.25      0.11     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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REFERENCES

20 SIGMA-(1198,JP=1/2+)I=1


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BRCWN    58 CERN CONF 270      BROWN,GLASER,GRAVES,PERL,CRONIN +    (MICH)
EISLER   58 NC SER10 10 150    EISLER,BASSI,CONVERSI +  (COL+BNL+BOL+PISA)

BARKAS   61 PR 124 1209        BARKAS,DYER,MASON,NICKOLS,SMITH        (LRL)
CHIESA   61 NC 19 1171         A M CHIESA,B QUASSIATI,G RINAUDO     (TURIN)
HUMPHREY 62 PR 127 1305        W E HUMPHREY,R R ROSS                  (LRL)
TRIPP    62 PRL 9 66           R D TRIPP,M WATSON,M FERRO-LUZZI       (LRL)

BARKAS   63 PRL 11 26          W H BARKAS,J N DYER,H H HECKMAN        (LRL)
BURNSTEI 64 PRL 13 66          BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW   (MARY)
COURANT  64 PR 136 B 1791      COURANT,FILTHUTH+  (CERN+HEIDLB+MD+NRL+BNL)
MILLER   64 PL 11 262          MILLER,STANNARD,BEZAGUET+ (LOND+PARIS+BERG)
MURPHY   64 PR 134 B 188       C THORNTON MURPHY                (WISCONSIN)
NAUENBER 64 PRL 12 679         NAUENBERG,SCHMIDT,MARATECK+ (COL+RUT+PRINC)

BAZIN    65 PR 140 B 1358      BAZIN,PLANO,SCHMIDT +    (PRINC+RUTG+COLUM)
DOSCH    65 PL 14 239          DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
  ALSC   66 PR  151  1081      CHUNG YUN CHANG                   (COLUMBIA)
SCHMIDT  65 PR 140 B 1328      P SCHMIDT                         (COLUMBIA)
BANGERTE 66 PRL  17  495       BANGERTER,GALTIERI,BERGE,MURRAY+       (LRL)
CHANG    66 PR  151 1081       CHUNG YUN CHANG                   (COLUMBIA)
CHIEN    66 PR  152  1171      +LACH,SANDWEISS,TAFT,YEH,OREN +   (YALE+BNL)

BARASH   67 PRL 19  181        BARASH,DAY,GLASSER,KEHOE,KNOP +   (MARYLAND)
BERLEY   67 PRL  19  979       BERLEY,HERTZBACH,KOFLER +   (BNL,MASS,YALE)

BIERMAN  68 PRL 20 1459        BIERMAN,KOUNOSU,NAUENBERG +      (PRINCETON)
GERSHWIN 68 PRL 20 1270        GERSHWIN,ALSTON-GARNJOST,BANGERTER+    (LRL)
HEPP     68 ZEIT.PHYS. 214 71  V.HEPP,H. SCHLEICH               (HEIDELBERG)
SECHIZOR 68 TO BE PUBL.        DAY,GLASSER,KNOP+ VIENNA 375       (MARYLAND)
WHITESID 68 NC  54A  537       H. WHITESIDE,J. GOLLUB              (OBERLIN)

ANG      69 ZPHY 228 151       +EBENHOR,EISELE,ENGELMANN,FILTHUTH+  (HEID)
ANG 1    69 ZPHY 228 151       +EISELE,ENGELMANN,FILTHUTH,FOHLISCH+ (HEID)
BAGGETT  69 PRL 23 249         BAGGETT,KEHOE,SNOW            (UNIV MARYLAND)
BALTAY   69 PRL 22 615         BALTAY,FRANZINI,NEWMAN,NORTON+  (COLU,STON)
BANGERTE 69 UCRL-19244         ROGER ODELL BANGERTER (THESIS)          (LRL)
BANGERT1 69 PR NOV 25          BANGERTER,GARNJOST,GALTIERI,GERSHWIN+ (LRL)
BARLOUTA 69 NP TO BE PUBLIS.   BARLOUTAUD,BELLEFON,GRANET+(SACL+CERN+HEID)
BERLEY   69 PR TO BE PUBLISH.  +KOFLER, YAMAMOTO,WILLIS +
COLLERAI 69 PRL 23 198         COLLERAINE,DAY,GLASSER,KNOP+(UNIV MARYLAND)
EISELE1  69 ZPHY 221 1         +ENGELMANN,FILTHUTH,FOHLISCH,HEPP+     (HEID)
EISELE2  69 ZPHY 223 487       EISELE,ENGELMANN,FILTHUTH,FOHLISCH+    (HEID)
GERSHWIN 69 UCRL-19246         LAWRENCE KENNETH GERSHWIN (THESIS)      (LRL)
NORTON   69 NEVIS 175 (THESIS) HERBERT NORTON                    (COLUMBIA)
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PAPERS NOT REFERRED TO IN DATA CARDS


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BROWN    57 PR 108 1036        J BROWN, D GLASER, M PERL  (MICHIGAN + BNL)
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Σ^0 21 SIGMA 0 (1193,JP=1/2+) I=1

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                  21  (SIGMA-) - (SIGMA0) MASS DIFFERENCE (MEV)
D1  N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

D1       18    4.75      0.1             BURNSTEIN 64 HBC
D1       37    4.87      0.12            DOSCH     65 HBC
D1       12    4.99      0.13            SCHMIDT   65 HBC  SEE NOTE N        6/68
D1           . . . . . . . . . .
D1  AVG        4.849     0.069   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
D1  FIT        4.86      0.07     VALUE FROM CONSTRAINED FIT                  6/68

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                  21  (SIGMA 0) - (LAMBDA) MASS DIFFERENCE (MEV)

DL  N   SEE NOTE PRECEDING LAMBDA MASS LISTINGS.

DL      208    76.63     0.28            SCHMIDT   65 HBC  SEE NOTE N        6/68
DL           . . . . . . . . . .
DL  FIT        76.86     0.09     VALUE FROM CONSTRAINED FIT                  6/68

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                  21  SIGMA0 LIFETIME (UNITS 10**-14)

T          1.0 OR LESS                   DAVIS     62 EMUL

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             21  SIGMA 0 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1       SIGMA 0 INTO LAMBDA GAMMA                      1115+   0
P2       SIGMA 0 INTO LAMBDA E+ E-                      1115+  .5+  .5

R1      SIGMA 0 INTO(LAMBDA E+ E-)/TOTAL                (P2)/(P1+P2)

R1            (0.0054)   THEORET. CAL. FEINBERG  58        QUANTUM ELECT.    9/66

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REFERENCES

21 SIGMA 0(1193,JP=1/2+)I=1


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FEINBERG 58 PR 109 1019        G.FEINBERG                             (BNL)
DAVIS    62 PR 127 605         D DAVIS,R SETTI,M RAYMOND,G TOMASIN    (CHI)
BURNSTEI 64 PRL 13 66          BURNSTEIN,DAY,KEHOE,SECHI ZORN,SNOW   (MARY)
DOSCH    65 PL 14 239          DOSCH,ENGELMANN,FILTHUTH,HEPP,KLUGE+ (HEID)
SCHMIDT  65 PR 140 B 1328      P SCHMIDT                         (COLUMBIA)
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QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS


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ALFF     65 PR 137 B1105       ALFF,GELFAND,NAUENBERG+ (COLUMBIA+RUTG+BNL)P
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PAPERS NOT REFERRED TO IN DATA CARDS


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COURANT  63 PRL 10 409         COURANT,FILTHUTH,FRANZINI+ (CERN+UMD+USNRL)
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Ξ^- 22 XI- (1321,JP=1/2) I=1/2

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                  22  XI-  MASS (MEV)

M   H   11(1317.0)    (2.2)              WANG      61 HLBC
M   H   18(1317.9)    (1.9)              FOWLER    61 HLBC
M   H (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
M        1(1322.0)    (1.3)              BROWN     62 HBC     ANTI-XI-        7/66
M      517 1321.4      0.4               JAUNEAU   63 FBC
M       62 1321.1      0.65              SCHNEIDER 63 HBC
M      241 1321.1      0.3               BADIER1   64 HBC
M       ALL MASSES ABOVE WERE RAISED 0.09 MEV BECAUSE LAMBDA MASS RAISED
M      149 1321.3      0.4               PJERROU   65 HBC                    11/67
M        5 1320.69     0.93              CHIEN     66 HBC  +  6.9 PBAR P,ANTI 9/67
M        6 1321.67     0.52              CHIEN     66 HBC  -  6.9 PBAR P      9/67
M      299 1321.4      1.1               LONDON    66 HBC                     6/66
M   S   12(1321.7)    (0.6)              SHEN      67 HBC     ANTI-XI-       10/67
M   S   THE ERROR IS STATISTICAL ONLY
M            . . . . . . . . . .
M   AVG    1321.26     0.18    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
M   FIT    1321.25     0.18     VALUE FROM CONSTRAINED FIT                    6/68

                  22  MASS DIFFERENCE,(XI-)-(ANTI-XI-) IN MEV

DM            1.0       1.1              CHIEN     66 HBC     6.9 PBAR P      9/67

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Data in parentheses have not been included in our averages.

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                     22  XI-  LIFETIME (UNITS 10**-10)

T   H   11   (3.5)    (3.4)    (1.23) WANG       61 HLBC
T   H   18   (1.28)   (0.41)   (0.25) FOWLER     61 HLBC
T   H (OLD DATA AND LOW STATISTICS DROPPED ON SUGGESTION OF J R HUBBARD)
T      517    1.86     0.15     0.14  JAUNEAU    63 FBC
T       62    1.55     0.31     0.31  SCHNEIDER 63 HBC
T      356   (1.77)   (0.12)          CARMONY    64 HBC    REP BY PJERROU 65
T      794    1.69     0.07           HUBBARD    64 HBC
T      246    1.70     0.12           PJERROU    65 HBC                        11/67
T   S    6   (1.37)   (0.51)          CHIEN      66 HBC  -  6.9 PBAR P          9/67
T   S    5   (1.51)   (0.55)          CHIEN      66 HBC  +  6.9 PBAR P,ANTI     9/67
T      299    1.80     0.16           LONDON     66 HBC                         6/66
T   S   12   (1.9)    (J.7)    (0.5)  SHEN       67 HBC     ANTI-XI-           10/67
T     2610    1.61     0.04           DAUBER     69 HBC                         6/68
T   S   THE ERROR IS STATISTICAL ONLY
T           • • • • • • • • •
T   AVG       1.660    0.037    0.035 AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                     22  XI- PARTIAL DECAY MODES

                                                              DECAY MASSES
P1      XI- INTO LAMBDA PI-                                  1115+ 139
P2      XI- INTO LAMBDA E- NEUTRINO                          1115+  .5+   0
P3      XI- INTO NEUTRON PI-                                  939+ 139
P4      XI- INTO LAMBDA MU- NEUTRINO                         1115+ 105+   0
P5      XI- INTO SIGMAO E- NEUTRINO                          1192+  .5+   0
P6      XI- INTO SIGMAO MU- NEUTRINO                         1192+ 105+   0
P7      XI- INTO NEUTRON E- NEUTRINO                          939+  .5+   0

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                     22  XI- BRANCHING RATIOS

R1      XI- INTO (LAMBDA E- NEU)/(LAMBDA PI-) (UNITS 10**-3) (P2)/(P1)
R1        1      (155)EFFECTIVE DENOM.  CARMONY    63 HBC                      11/67
R1        0      (260)EFFECTIVE DENOM.  JAUNEAU    63 HBC                      11/67
R1        0      (220)EFFECTIVE DENOM.  BERGE      66 HBC                      11/67
R1        1      (155)EFFECTIVE DENOM.  LONDON     66 HBC                      11/67
R1        0      (717)EFFECTIVE DENOM.  TRIPPE     67 HBC                      11/67
R1        2 .   (1976)EFFECTIVE DENOM.  HUBBARD    68 HBC                       6/68
R1        4    1.5       0.90     0.55  HUBBARD    68 RVUE                      6/68
R1       HUBBARD 68 (RVUE) INCLUDES ALL ABOVE EVENTS                            6/68

R2      XI- INTO (NEUTRON PI-)/(LAMBDA PI-) (UNITS 10**-3) (P3)/(P1)
R2           (5.0)  OR LESS             FERRO-LUZ 63 HBC                        6/68
R2           (1.1)  OR LESS             DAUBER     69 HBC                       6/68

R3      XI- INTO (LAMBDA MU- NEUTRINO)/TOTAL (UNITS 10**-3) (P4)/TOTAL
R3          (12.0)  OR LESS             BERGE      66 HBC                       6/68
R3           (1.3)  OR LESS             DAUBER     69 HBC                       6/68

R4      XI- INTO (SIGMAO E- NEUTRINO)/TOTAL (UNITS 10**-3) (P5)/TOTAL
R4           (3.0)  OR LESS             BERGE      66 HBC                       6/68
R4           (0.5)  OR LESS             DAUBER     69 HBC                       6/68

R5       I  XI- INTO (SIGMAO MU- NEUTRINO)/TOTAL          (P6)/TOTAL
R5          (0.005)  OR LESS            BERGE      66 HBC                       7/66

R6          XI- INTO (N E- NEUTRINO) / (LAMBDA PI-)       (P.7)/(P1)
R6           (0.01) OR LESS             BINGHAM    65 RVUE   CONF.LIMIT 0.9     9/66

R7      XI- INTO (SIGMAO E NEU + LAMBDA E NEU)/TOTAL (10**-3) (P2 +P5)/TOTAL
R7        14    0.62     0.20     0.30  DUCLOS     68 OSPK   PREL.SEE NOTE D   10/68
R7  D    THIS EXPERIMENT CANNOT DISTINGUISH SIGMAO FROM LAMBDA. THE CABIBBO
R7  D    THEORY EXPECT SIGMAO RATE ABOUT A FACTOR 6 SMALLER THAN THE LAMBDA
R7  D    TO GET A VALUE FOR THE TABLE R7 HAS BEEN AVERAGED WITH R1 -

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                     22  XI- DECAY PARAMETERS

A       ALPHA XI-
A   O        (-0.44)   (0.12)           JAUNEAU    63 FBC    SEE NOTE D BELOW  6/68
A   O    62  (-0.73)   (0.23)           SCHNEIDER 63 HBC    SEE NOTE D BELOW  6/68
A       240   -0.5      0.38            BADIER1    64 HBC    SEE NOTE D BELOW  6/68
A       356   -0.62     0.13            CARMONY    64 HBC    SEE NOTE D BELOW  6/68
A      1004   -0.365    0.068           BERGE      66 HBC    SEE NOTE D BELOW  6/68
A   L   364   -0.47     0.13            LONDON     66 HBC    SEE NOTE D BELOW  6/68
A            (-0.391)  (0.032)          BERGE 2    66 RVUE  INCLUDES ALL ABOVE 9/66
A    M 2529  (-0.375)  (0.051)          MERRILL    68 HBC                      6/68
A      2781   -0.391    0.045           DAUBER     69 HBC    SEE NOTE A BELOW
A   A   USED ALPHALAMBDA = 0.647 PLUS OR MINUS 0.020
A   D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A   D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)                  6/68
A   L   LONDON 66 USES ALPHA-LAMBDA = 0.62
A   M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
A   O   OLD DATA NOT INCLUDED IN AVERAGE.
A            • • • • • • • • •
A   AVG      -0.407    0.037   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

F       PHI ANGLE (SIN(PHI)/COS(PHI)=BETA/GAMMA) (DEGREES)
F   O        (-16.0)   (45.0)           JAUNEAU    63 FBC    SEE NOTE D BELOW  6/68
F   O    62  (45.0)    (36.0)           SCHNEIDER 63 HBC    SEE NOTE D BELOW  6/68
F       356   54.0      30.0            CARMONY    64 HBC    SEE NOTE D BELOW  6/68
F      1004    0.       12.             BERGE      66 HBC    SEE NOTE D BELOW  6/68
F   L   364    0.0      20.4            LONDON     66 HBC    SEE NOTE D BELOW  6/68
F    M 2529   (9.8)    (11.6)           MERRILL    68 HBC                      6/68
F      2781  -14.       11.             DAUBER     69 HBC    SEE NOTE A BELOW
F   A   USED ALPHALAMBDA = 0.647 PLUS OR MINUS 0.020
F   D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F   D   POLARIZATION. (SEE DAUBER 68 FOR DETAILED DISCUSSION)
F   L   LONDON 66 USES ALPHA-LAMBDA = 0.62
F   M   DATA OF MERRILL 68 INCLUDED IN DAUBER 68.
F   O   OLD DATA NOT INCLUDED IN AVERAGE.
F            • • • • • • • • •
F   AVG      -3.0      9.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                     (SEE IDEOGRAM BELOW )
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REFERENCES

22 XI - (1321,JP=1/2) I=1/2


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FOWLER    61 PRL 6 134          FOWLER,BIRGE,EBERHARD,ELY,GOOD,POWELL+(LRL)
WANG      61 JETP 13 512        K WANG,T WANG,VIRYASOV,TING,SOLOVEV+ (JINR)
BROWN     62 PRL 8 255          BROWN,CULWICK,FOWLER,GAILLOUD +  (BNL+YALE)

CARMONY  63 PRL  10  381        CARMONY,PJERROU                      (UCLA)
FERRO-LU 63 PR 130 1568         FERRO-LUZZI,ALSTON,ROSENFELD,WOJCICKI (LRL)
JAUNEAU  63 SIENA CONF 4        JAUNEAU+       (PARIS+CERN+LOND+RUTH+BERGEN)
   ALSO 63 PL  5  261           JAUNEAU,MORELLET+ (EP,CERN,LON,RUTH,BERGEN)
SCHNEIDE 63 PL 4 360            H SCHNEIDER                          (CERN)

CARMONY  64 PRL 12 482          CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA)
BADIER1  64 DUBNA CONF I 593    BADIER,DEMOULIN,BARLOUTAUD+ (PARIS+SAC+ZEE)
HUBBARD  64 PR 135 B 183        HUBBARD,BERGE,KALBFLEISCH,SHAFER +    (LRL)
BINGHAM  65 PRSL  285  202      H H BINGHAM                          (CERN)
PJERRCU  65 PRL 14 275          + SCHLEIN,SLATER,SMITH,STORK,TICHO   (UCLA)
PJERROU  65 THESIS              G M PJERROU                          (UCLA)

BERGE    66 PR  147  945        BERGE,EBERHARC,HUBBARD,MERRILL +      (LRL)
BERGE 2  66 BERKELEY CONF 46    BERGE,CABIBBO                        (RVUE)
LONDON   66 PR 143 1034         LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL+SYRACUS)
CHIEN    66 PR  152  1171       +LACH,SANDWEISS,TAFT,YEH,OREN +  (YALE+BNL)
SHEN     67 PL 25 B 443         B.C.SHEN,A.FIRESTONE,G.GOLDHABER  (UCB+LRL)
TRIPPE   67 PRIV. COMM.         T. TRIPPE                            (UCLA)
DUCLOS   68 TO BE PUBL.         DUCLOS,FREYTAG+ VIENNA 253(CERN,HEIDELBERG)
HUBBARD  68 PRL 20 465          HUBBARD,BERGE,DAUBER                  (LRL)
MERRILL  68 PR 167 1202         MERRILL,SHAFER                        (LRL)J
DAUBER   69 PR  179 1272        +BERGE,HUBBARD,MERRILL,MILLER         (LRL)J

         QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

CARMONY  64 PRL 12 482    •     CARMONY,PJERROU,SCHLEIN,SLATER,STORK+(UCLA) J
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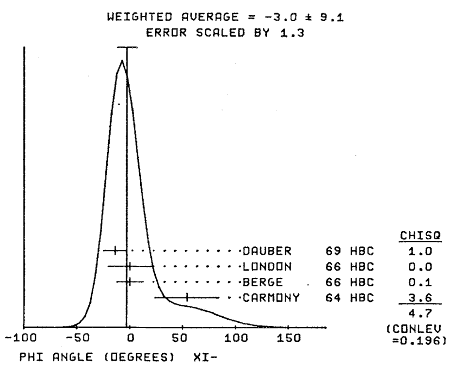


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                     23  XI 0  (1314,JP=1/2 ) I=1/2

                     23  XI 0  MASS (MEV)

M         1 1313.4     1.8              PALMER     68 HBC                       3/68
M           • • • • • • • • • •
M   FIT    1314.69     0.70      VALUE FROM CONSTRAINED FIT                     6/68

                     23  XI       MASS DIFFERENCE (-)-(0)(MEV)

D        23    6.8     1.6              JAUNEAU    63 FBC
D        45   (6.1)   (1.6)             CARMONY    64 HBC    REP BY PJERROU 65
D        88    6.1     0.9              PJERRCU    65 HBC                      11/67
D        29    6.9     2.2              LONDON     66 HBC                       6/66
D           • • • • • • • • • •
D   AVG        6.34    0.74      AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.0)
D   FIT        6.56    0.68      VALUE FROM CONSTRAINED FIT                     6/68

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                     23  XI 0 LIFETIME (UNITS 10**-10)

T        24    3.9     1.4      0.80  JAUNEAU    63 FBC
T        45   (3.5)   (1.0)    (0.8)  CARMONY    64 HBC    REP BY PJERROU 65
T       101    2.5     0.4      0.3   HUBBARD    64 HBC
T        80    3.0     0.5            PJERRCU    65 HBC                        11/67
T       340    3.07    0.22     0.20  DAUBER     69 HBC                         6/68
T           • • • • • • • • • •
T   AVG        3.03    0.18     0.16    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                     23  XI 0  PARTIAL DECAY MCDES

                                                              DECAY MASSES
P1      XI 0 INTO LAMBDA PIO                                 1115+ 134
P2      XI 0 INTO PROTON PI-                                  938+ 139
P3      XI 0 INTO PROTON E- NEU                               938+  .5+   0
P4      XI 0 INTO SIGMA+ E- NEU                              1189+  .5+   0
P5      XI 0 INTO SIGMA- E+ NEU                              1197+  .5+   0
P6      XI 0 INTO SIGMA+ MU- NEUTRINO                        1189+ 105+   0
P7      XI 0 INTC SIGMA- MU+ NEUTRINO                        1197+ 105+   0
P8      XI 0 INTO PROTON MU- NEUTRINO                         938+ 105+   0

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                     23  XI 0  BRANCHING RATICS

R1      XIO INTO (PROTON PI-)/(LAMBDA PIO) (UNITS 10**-3) (P2)/(P1)
R1          (27.0)  OR LESS             TICHO      63 HBC                       6/68
R1           (5.0)  OR LESS             HUBBARD    66 HBC                       6/68
R1           (0.9)  OR LESS             DAUBER     69 HBC                       6/68

R2      XIO INTO (PROTON E- NEU)/(LAMBDA PIO) (UNITS 10**-3) (P3)/(P1)
R2          (27.0)  OR LESS             TICHO      63 HBC                       6/68
R2           (6.0)  OR LESS             HUBBARD    66 HBC                       6/68
R2           (1.3)  OR LESS             DAUBER     69 HBC                       6/68

R3      XIO INTO (SIGMA+ E- NEU)/(LAMBDA PIO) (UNITS 10**-3) (P4)/(P1)
R3          (13.0)  OR LESS             TICHO      63 HBC                       6/68
R3           (7.0)  OR LESS             HUBBARD    66 HBC                       6/68
R3           (1.5)  OR LESS             DAUBER     69 HBC                       6/68
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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R4     XI0 INTO (SIGMA- E+ NEU)/(LAMBDA PI0) (UNITS 10**-3) (P5)/(P1)
R4          (6.0)  OR LESS            HUBBARD   66 HBC                   6/68
R4          (1.5)  OR LESS            DAUBER    69 HBC                   6/68

R5     XI0 INTO (SIGMA+ MU- NEU)/TOTAL (UNITS 10**-3) (P6)/TOTAL
R5          (7.0)  OR LESS            HUBBARD   66 HBC                   6/68
R5          (1.5)  OR LESS            DAUBER    69 HBC                   6/68

R6     XI0 INTO (SIGMA- MU+ NEU)/TOTAL (UNITS 10**-3) (P7)/TOTAL
R6          (6.0)  OR LESS            HUBBARD   66 HBC                   6/68
R6          (1.5)  OR LESS            DAUBER    69 HBC                   6/68

R7     XI0 INTO (PROTON MU- NEU)/TOTAL  (UNITS 10**-3) (P8)/TOTAL
R7          (6.0)  OR LESS            HUBBARD   66 HBC                   6/68
R7          (1.3)  OR LESS            DAUBER    69 HBC                   6/68
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                    23  XI 0 DECAY PARAMETER

A       ALPHA XI 0
A             -0.09     0.46          PJERROU   65 HBC    SEE NOTE D BELOW  6/68
A       146   -0.13     0.17          BERGE     66 HBC    SEE NOTE D BELOW  6/68
A   L    46   -0.2      0.4           LONDON    66 HBC    SEE NOTE D BELOW  6/68
A    M  490  (-0.33)   (0.11)         MERRILL   66 HBC    SEE NOTE D BELOW  6/68
A   A   739   -0.43     0.09          DAUBER    69        SEE NOTE A BELOW
A   A    USED ALPHALAMBDA = 0.647 PLUS OR MINUS 0.020
A    D   ERRORS MULTIPLIED BY 1.1 DUE TO APPROXIMATIONS USED FOR XI
A    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
A   L    LONDON 66 USES ALPHA-LAMBDA = 0.62
A    M   MERRILL 66 REPLACED BY DAUBER 69
A             . . . . . . . . . .
A   AVG       -0.351    0.077   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

F       PHI ANGLE  (SIN(PHI)/COS(PHI)=BETA/GAMMA)  (DEGREES)
F       146   -8.       30.           BERGE     66 HBC    SEE NOTE D BELOW  6/68
F    M  490 (107.0)    (46.0)         MERRILL   66 HBC    SEE NOTE D BELOW  6/68
F   A   739   38.       19.           DAUBER    69 HBC    SEE NOTE A BELOW
F   A    USED ALPHALAMBDA = 0.647 PLUS OR MINUS 0.020
F    D   ERRORS MULTIPLIED BY 1.2 DUE TO APPROXIMATIONS USED FOR XI
F    D   POLARIZATION. (SEE DAUBER 69 FOR DETAILED DISCUSSION)
F    M   MERRILL 66 REPLACED BY DAUBER 69
F             . . . . . . . . . .
F   AVG       24.8      20.8    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW )
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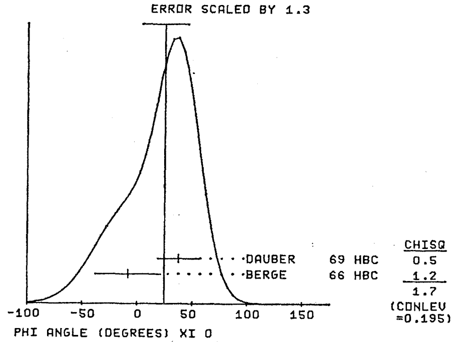
WEIGHTED AVERAGE = 24.8 ± 20.8
ERROR SCALED BY 1.3



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                          REFERENCES

                          23 XI 0(1314,JP=1/2)I=1/2

ALVAREZ  59 PRL 2 215       ALVAREZ,EBERHARD,GOOD,GRAZIANO,TICHO+ (LRL)
JAUNEAU  63 SIENA CONF 1 1  JAUNEAU+      (PARIS+CERN+LOND+RUTH+BERGEN)
    ALSO 63 PL 4 49         JAUNEAU+      (PARIS+CERN+LOND+RUTH+BERGEN)
TICHO    63 BNL CONF 410    HAROLD K TICHO                         (UCLA)

CARMONY  64 PRL 12 482      CARMONY,PJERRCU,SCHLEIN,SLATER,STORK+(UCLA)
HUBBARD  64 PR 135 B 183    HUBBARD,BERGE,KALBFLEISCH,SHAFER +     (LRL)
PJERRCU  65 PRL 14 275      + SCHLEIN,SLATER,SMITH,STORK,TICHO    (UCLA)
PJERROU  65 THESIS          G M PJERROU                           (UCLA)

BERGE    66 PR  147  945    BERGE,EBERHARD,HUBBARD,MERRILL +       (LRL)
HUBBARD  66 UCRL 11510      J RICHARD HUBBARD (THESIS,BERKELEY)    (LRL)
LONDON   66 PR 143 1034     LONDON,RAU,GOLDBERG,LICHTMAN+ (BNL+SYRACUS)
MERRILL  66  BERKELEY CONF  MERRILL,SHAFER,BERGE                   (LRL)
  .CF.   66 UCRL 16455      DEANE MERRILL (THESIS, BERKELEY)       (LRL)

PALMER   68 PL 26B  323     PALMER,RADOJICIC,RAU,RICHARDSON+  (BNL,SYR)
DAUBER   69 PR  179 1262    +BERGE,HUBBARD,MERRILL,MILLER          (LRL)
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              24  OMEGA- (1675,JP=3/2+)  I=0

            QUANTUM NUMBERS ASSIGNED FROM SU3

          THERE ARE 28 REPORTED OMEGA- EVENTS
          SEE PREVIOUS EDITION (RMP 41 109) FOR MORE DETAILS

                 24  OMEGA-  MASS (MEV)

M         1(1620.0)   (25.0)   (10.0) EISENBERG 54 EMUL
M         1 1673.0      8.0           ABRAMS    64 HBC   INTO XI- PIO
M         3 1673.3      1.0           PALMER    68 HBC   K-P 4.6,5. GEV/C 11/69*
M         3 1671.8      0.8           SCHULTZ   68 HBC   K-P 5.5 GEV/C    11/69*
M         5 1674.2      1.6           SCOTTER   68 HBC   K-P 6.  GEV/C    11/69*
M         6 1671.9      1.2           SPETH     69 HBC   K-P 10. GEV/C    11/69*
M          . . . . . . . . .
M   AVG     1672.49     0.52    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
                        (SEE IDEOGRAM BELOW )
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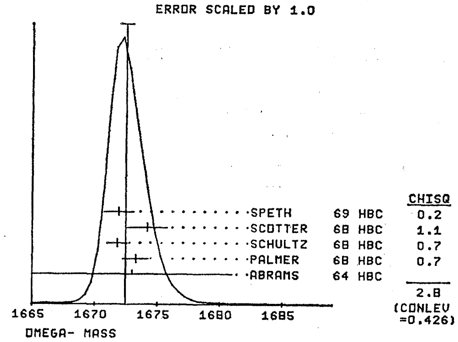
WEIGHTED AVERAGE = 1672.49 ± 0.52
ERROR SCALED BY 1.0



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                 24  OMEGA- LIFETIME  (UNITS 10**-10 SEC)

T   A   1  (1.63)                 ABRAMS    64 HBC                  7/66
T   A   1  (0.7)                  BARNES 1  64 HBC                  7/66
T   A   1  (1.4)                  BARNES 2  64 HBC                  7/66
T   A   1  (1.85)                 COLLEY    65 HBC                  7/66
T   A   1  (1.5)                  RICHARDSO 65 HBC                  7/66
T   A   1  (0.93)                 ABCLV COL 68 HBC                 11/67
T   A   1  (2.6)                  ABCLV CCL 68 HBC                 11/67
T   A   1  (1.6)                  ABCLV CCL 68 HBC                 11/67
T   A   1  (0.21)                 ABCLV COL 68 HBC                 11/67
T   A   1  (1.20)                 SCHULTZ   68 HBC                 11/67
T   A   1  (0.06)                 SCHULTZ   68 HBC                 11/67
T.  A   1  (0.63)                 SCHULTZ   68 HBC                 11/67
T   A   1  (0.25)                 SCOTTER   68 HBC                  6/68
T   A   1  (0.30)                 SCOTTER   68 HBC                  6/68
T   A   1  (0.71)                 SCOTTER   68 HBC                  6/68
T   A   1  (0.08)                 SCOTTER   68 HBC                  6/68
T   A   1  (1.04)                 SCOTTER   68 HBC                  6/68
T   A   1  (2.38)                 SCOTTER   68 HBC                  6/68
T   A  ALLISON INCLUDES ALL ABOVE + 3 MORE BNL EVENTS, UNPUBLISHED.     6/68
T      21    1.31     0.37    0.24 ALLISON  68 RVUE                 6/68
T       1 (2.3)                   SPETH     69 HBC                 10/69*
T       1 (0.31)                  SPETH     69 HBC                 10/69*
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                 24 OMEGA- PARTIAL DECAY MODES

                                                       DECAY MASSES
P1  OMEGA- INTO LAMBDA K-                              938+ 105+   0
P2  OMEGA- INTO XI 0 PI-                               938+ 105+   0
P3  OMEGA- INTO XI- PI 0                               938+ 105+   0
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                 24  CMEGA- BRANCHING RATIOS

    27 EXAMPLES OF OMEGA - DECAYS HAVE BEEN REPORTED.  16 HAVE
    DECAYED INTO LAMBDA K-, 9 INTO XIO PI-, 2 INTO XI- PIO, AND ONE IS
    AMBIGUOUS BETWEEN LAMBDA K- AND XIO PI-.
    1 BNL EVENT HAS NOT BEEN DESCRIBED.

R1        OMEGA- INTO LAMBDA K-                          P1
R1      2   EVENTS                    PALMER    68 HBC                 11/69*
R1      3   EVENTS                    SCHULTZ   68 HBC                 11/69*
R1      5   EVENTS   1 AMBIG. XIO PI- SCOTTER   68 HBC                 11/69*
R1      6   EVENTS                    SPETH     69 HBC                 11/69*

R2        OMEGA- INTO XIO PI-                            P2
R2      1   EVENTS                    ABRAMS    64 HBC                 11/69*
R2      4   EVENTS                    PALMER    68 HBC                 11/69*
R2      3   EVENTS                    SCOTTER   68 HBC                 11/69*
R2      1   EVENT                     SPETH     69 HBC                 11/69*

R3        OMEGA- INTO XI- PIO                            P3
R3      1   EVENT                     PALMER    68 HBC                 11/69*
R3      1   EVENT                     SCOTTER   68 HBC                 11/69*
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                          REFERENCES
                          24 OMEGA-(1675,JP=3/2+)  I=0

EISENBER 54 PR 96 541         Y EISENBERG                         (CORNELL)
ABRAMS   64 PRL 13 670        + BURNSTEIN,GLASSER +         (MARYLAND+USNRL)
BARNES 1 64 PRL  12  204      V E BARNES,CONNOLLY,CRENNELL,CULWICK+ (BNL)
BARNES 2 64 PL 12 134         V E BARNES,CONNOLLY,CRENNELL,CULWICK+ (BNL)
COLLEY   65 PL 19 152         COLLEY,DODD +       (BIR+GLA+IC+MUN+OXF+RHEL)
RICHARDS 65 BAPS 10 115       RICHARDSON,BARNES,CRENNEL+    (BNL+SYRACUSE)
SAMIOS   65 ARGONNE CONF 189  N P SAMIOS                         ((RVUE) BNL)

ABCLV CO 68 NUC PHYS B4 326   AACHEN+BERLIN+CERN+LONDON IMP.COLL.+VIENNA
ALLISCN  68 PRIV. COMM.       JOHN ALLISON                        (LANCASTER)
PALMER   68 PL 26B 323        PALMER,RADOJICIC,RAU,RICHARDSON+  (BNL,SYR)
SCHULTZ  68 PR  168  1509     SCHULTZ+     (ILL,ARGONNE,NORTHWESTERN,WISC)
SCOTTER  68 PL 26B 474        SCOTTER+(BIRM,GLASGOW,IC LONDON,MUNICH,OXF)
SPETH    69 PL  29B 252       SPETH+   (AACHEN,BERLIN,CERN,LONDON,VIENNA)
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Data in parentheses have not been included in our averages.

CODE EVENTS ABOVE BACKGROUND QUANTITY ERROR+ ERROR- REFERENCE YR TECN SIGN COMMENTS DATE PUNCHED

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PI MESON (JPG=0--) I=1
SEE LISTING OF STABLE PARTICLES

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$\sigma(410)$ →

7 SIGMA MESON (410, JPG=0++) I = 0
NO EVIDENCE FOR RESONANCE
OMITTED FROM TABLE.
SEE NOTE ON ETA 0+(700)

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REFERENCES ON SIGMA

SAMIOS 62 PRL 9 139 +BACHMAN,LEA+ (BNL+CCNY+CO+KY)
BLOKHINT 63 JETP 17 80 BLOKHINTSEVA,GREIBINNIK,ZHUKOV + (DUBNA)
BOOTH 63 PR 132 2314 + ABASHIAN (LRL)
KIRZ 63 PR 130 2481 +SCHWARTZ + TRIPP (LRL)

BARISH 64 PR 135 B 416 BARISH,KURZ,PEREZ-MENDEZ,SOLOMON (LRL)
CRAWFORD 64 PRL 13 421 +GROSSMAN,LLOYD,PRICE,FOWLER (LRL)
DEL FABR 64 PRL 12 674 DEL FABRO,DE PRETIS,JONES+ FRASCATI
KALMUS 64 PRL 13 99 +KERNAN,PU,POWELL,DOWD (LRL+WISCONSIN)

BIRGE 65 PR 139 B 1600 +ELY+GIDAL+KALMUS+CAMERINI+ (LRL+WISC)
BROWN 65 CORAL GABLES 219 BROWN+FAIER (NORTHWESTERN)
WOLF 65 PL 19 328 WOLF (DESY)

JACOBS 66 PRL 16 669 +SELOVE (LRL)
KOPELMAN 66 PL 22 118 +ALLEN,GOODEN,MARSHALL + (COLORADO+IOWA)
LOVELACE 66 PL 22 332 LOVELACE,HEINZ,DONNACHIE (CERN)

ANDERSON 67 PRL 18 89 +FUKUI+KESSLER+ (CHIC+ANL+OTT+MCGILL+QMC)
CORBETT 67 PR 156 1451 +DAMERELL+MIDDLEMAS+NEWTON OXF+RUTHERF
MALAMUD 67 PRL 19 1056 E.MALAMUD + P.E.SCHLEIN (UCLA)
WALKER 67 PRL 18 630 +CARROLL,GARFINKEL,OH (WISCONSIN)

BANDER 68 PR 168 1679 M. BANDER, G.L. SHAW, J.R. FULCO (UCI+UCSB)
BISWAS 68 PL 27 B 513 +CASON,JOHNSON,KENNEY,POIRIER+ (NOTRE DAME)
EISENHAN 68 PRL 20 758 EISENHANDLER,MISTRY,MOSTEK + (CORNELL)
FOSTER 68 NP B 6 107 +GAVILLET+LABROSSE+MONTANET+ (CERN+PARIS)
JONES 68 PR 166 1405 +CALDWELL+ZACHAROV+HARTING+BLEULER+ (CERN)
MARATECK 68 PRL 21 1613 +HAGOPIAN,+ (PENN+LRL+COLO+PURD+TNTO+WISC)

DAVISCN 69 PR 180 1333 +BACASTOW,BARKAS,+ (RIVS+BERK)
ELY 69 PR 180 1319 +GIDAL,HAGOPIAN,+ (BERK+LOUC+WISC)
GUTAY 69 NP B 12 31 +CARMONY,CSONKA,LOEFFLER,MEIERE (PURDUE)
ROBERTS 69 PL 29 B 368 R.G. ROBERTS, F. WAGNER (CERN)

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η

14 ETA (549, JPG=0-+) I=0
SEE LISTINGS OF STABLE PARTICLES

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$\eta_{0+}(\sim 700)$
"ϵ" $\to \pi\pi$

14 ETA 0+(700,JPG=0++) I=0
ALSO CALLED EPSILON (720)

The question of the existence of a $\pi\pi$ resonance in the I = 0 S wave at about 720 MeV is still not entirely settled; in particular its mass and width are not well known. The width determinations range from wide (150 MeV) to very wide (400 MeV), the very wide ones being preferred in recent studies. The possibility of a very wide resonance was first advocated by LOVELACE 66, who observed that, to interpret πN elastic scattering data in a dispersion-theoretic framework, one has to assume the exchange of such a $\pi\pi$ resonance in the t channel.

Although no method of $\pi\pi$ phase-shift analysis is free from serious objections, the fact that all such analyses of the $\pi^- p \to \pi^+\pi^- n$ reaction (CLEGG 67, GUTAY 67, MALAMUD 67, WALKER 67, JOHNSON 68, JONES 68, MARATECK 68, GUTAY 69) find the S-wave phase shift δ_{00} to be near 90 deg. in the 720-MeV region is quite impressive. These analyses cannot distinguish between the broad solution (the "down-up" solution) and the very broad solution (the "up-down" solution).

Similar analyses have been done by SMITH 69, studying the reaction $\pi^+ n \to \pi^+\pi^- p$ and comparing the solutions with their $\pi^+ n \to \pi^0\pi^0 p$ data, and by DEINET 69, who study the $\pi^- p \to \pi^0\pi^0 n$ reaction. Both favor the up-down solution.

Other direct observations of the $\pi^0\pi^0$ system, although with statistics inferior to DEINET 69, have been reported by BROWN 68, studying $\pi^+ d \to \pi^0\pi^0 pp$, and by CORBETT 67, FELDMAN 69, and STRUGALSKI 69, studying $\pi^- p \to \pi^0\pi^0 n$.

Further support is lent by different theoretical models which, when compared with a multitude of experimental information, require a very broad resonance. Thus the Veneziano model has been compared with $\bar{p}n \to \pi^+\pi^-\pi^-$, $\eta \to 3\pi$, and $K \to 3\pi$ data by LOVELACE 68, with $\pi^- p \to \pi^+\pi^- n$ and K_{e4} data by ROBERTS 69 and WAGNER 69, and with $\bar{p}p \to 4\pi$ data by HOPKINSON 69. DUTTA-ROY 68 compare a model with the Adler sum rule, the K_1-K_2 mass difference, the MALAMUD 67 phase shifts, backward πN dispersion relations, and different K decay phenomena. MORGAN 69 compare forward dispersion relations with K_{e4} data. This list far from exhausts the models that predict the resonance and agree with some set of experimental data.

Thus all information points to the existence of an S-wave resonance in the region 650 to 900 MeV, or at least δ_{00} is near 90 deg. in this region. Above 900 MeV there is little or no information. All that can be said about the resonance width is, then, that it is well over 100 MeV.

Data in parentheses have not been included in our averages.

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REFERENCES


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CLARK     65 PR 139 81556      +CHRISTENSON+CRONIN+TURLAY       (PRINCETON)
COHN      65 PRL 15 906        H O COHN,BUGG+ (ORNL+TENN+UNCAR+COLU+EFINS)
DURAND    65 PRL 14 329        L. DURAND AND Y.T. CHIU                (YALE)
FCPINC    65 PL 19 65          +GESSAROLI,LENOINARA+     (BOL+ORSAY+SACLAY)
WOLF      65 PL 19 328         G WOLF                                 (DESY)
LOVELACE  66 PL  22  332       LOVELACE,HEINZ,DONNACHIE               (CERN)

BANDER    67 PR 155 1675       M.BANDER + G.L.SHAW                     (UCI)
BUHLER    67 NC 49A 183        +DALPIAZ,MASSAM,ZICHICHI+     (CERN+BOLOGNA)
CLEGG     67 PR 163 1664       A.B.CLEGG                         (LANCASTER)
CORBETT   67 PR 156 1451       +DAMERELL+MIDDLEMAS+NEWTON     OXF+RUTHERF
GUTAY     67 PRL 18 142        +JOHNSON+LOEFFLER+MCILWAIN+    (PURDUE+UCRL)
MALAMUD   67 PRL 19 1056       E.MALAMUD + P.E.SCHLEIN                (UCLA)
WALKER    67 PRL 18 630        +CARROLL,GARFINKEL,OH             (WISCONSIN)
WALKER    67 RMP 39 695        W.D.WALKER                        (WISCONSIN)

ARMENISE  68 NC 54 A 999       +FORINO+CARTACCI+(BARI+BOLOG+FIRENZE+ORSAY)
BANDER    68 PR 168 1679       +SHAW,FULCO             (UC IRVINE+S.BARBARA)
BRAUN     68 PRL 21 1275       BRAUN,CLINE,SCHERER               (WISCONSIN)
DUTTA-RO  68 PR 169 1357       R. DUTTA-ROY, I.R. LAPIDUS      (HOBOKEN,NJ)
FCSTER    68 NP B 6 107        +GAVILLET+LABROSSE+MONTANET+    (CERN+PARIS)
JONES     68 PR 166 1405       +CALDWELL+ZACHAROV+HARTING+BLEULER+  (CERN)
JCHNSON   68 PR 176 1651       +POIRIER,BISWAS,GUTAY,DERADO+(ND+PURD+SLAC)
LOVELACE  68 PL 28 B 264       C.LOVELACE                             (CERN)
MARATECK  68 PRL 21 1613       +HAGOPIAN,+  (PENN+LRL+COLO+PURD+TNTO+WISC)
SMITH     68 PR 171 1399       G.A.SMITH, R.J.MANNING                 (UCRL)

DEINET    69  LUND CONF.       +MENZIONE,MULLER,STAUDENMAIER,+ (KARL+CERN)
FELDMAN   69 PRL 22 316        +FRATI,GLEESON,HALPERN,NUSSBAUM,+      (PENN)
GUTAY     69 NP B 12 31        +CARMONY,CSONKA,LOEFFLER,MEIERE      (PURDUE)
HOPKINSO  69 NC 59 A 181       J.HOPKINSON,R.G.ROBERTS                (CERN)
MORGAN    69 NP B 10 261       D.MORGAN,G.SHAW                        (RHEL)
ROBERTS   69 PL 29 B 368       R.G. ROBERTS, F. WAGNER                (CERN)
SMITH     69 PRL 23 335        G.A.SMITH, R.J.MANNING             (MICH+LRL)
STRUGALS  69 PL 29 B 518       +CHUVILC,FENYVES,+           (WARS+JINR+BUDA)
WAGNER    69  CERN TH-1012     F.WAGNER                               (CERN)
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ρ(765)

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        9 RHO (765, JPG = 1-+)  I=1

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        9 RHO  MASS (MEV)

 THERE ARE WIDE FLUCTUATIONS IN THE MEASURED VALUES FOR MASS AND WIDTH OF
 THE RHO DUE TO DIFFERENCES IN PRODUCTION MECHANISM, BACKGROUND, METHOD
 OF ANALYSIS AND PARAMETRIZATION.  UNCERTAINTIES IN THEORY GIVE RISE TO
 SYSTEMATIC ERRORS OF ABOUT 20 MEV IN MASS AND WIDTH.

THE FOLLOWING 8 ENTRIES ARE THE MOST SIGNIFICANT ONES. THEY ILLUSTRATE
THE DISCREPANCIES, AND ARE ALSO REPEATED IN FOOTNOTE (C) OF THE MESON
TABLE.

  1 AUGUSTIN2 69 (RHO 0 FROM E+E- COLL. BEAMS)
  2 AUSLANDER 68 (RHO 0 FROM E- E+ COLLIDING BEAMS)
  3 BATON 67     (RHO - IN CHEW-LOW EXTRAPOLATION AND PHASE SHIFT ANALYSIS)
  4 MALAMUD 67   (RHO 0 FROM PION-PION PHASE SHIFT ANALYSIS) MASS, NO WIDTH
  5 MARATECK 68  (RHO 0 IN CHEW-LOW EXTRAP. + PHASE SH. ANAL.) WIDTH, NO MA
                 NO MASS
  6 PISUT 68     (COMPILATION AND DISCUSSION OF RHO+-0 IN PI N COLLISIONS)
  7 ROOS 69      (COMPILATION OF RHO 0 FROM E+ E- COLLIDING BEAMS)
  8 SCHLEIN 68   (RHO 0 FROM PION-PION PHASE SHIFT ANALYSIS) WIDTH, NO MASS

M+  CHARGE PLUS ONLY
M+  R       (760.0)    (9.0)          CARMONY   64 HBC  +   3.5 PI+P,TCUT 4
M+           760.      10.            ARMENISE  65 HBC, +   2.8 PI+P
M+  R       (765.0)    (5.0)          ALFF-STEI 66 HBC  +   2-3 PI+ P        6/66
M+  R       (783.0)    (6.0)          JAMES     66 HBC  +   2.1 PI+ P        6/66
M+  R       (758.0)   (10.0)          JAMES     66 HBC  +   2.1 PI+,TCUT2.5  8/66
M+           777.0      7.0           ABC COLL. 68 HBC  +   8 PI+P TO P+3PI  5/68
M+          . . . . . . . . . .
M+  AVG      771.4      8.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

M+  CHARGE PLUS AND MINUS
M+  S       (750.0)    (3.0)          BALTAY    66 HBC  +-  0.0 PBAR P       6/66
M+           755.      10.            ALLES-BUR 67 HBC  +-  5.7 PBAR P      12/66
M+           730.      11.            BARLOW    67 HBC  +-  1.2 PBAR P      11/66
M+           782.       5.            FOSTER    68 HBC  +-  PBAR P AT REST   6/68
M+.         . . . . . . . . . .
M+  AVG      770.0     13.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.3)

M-  CHARGE MINUS ONLY
M-          (748.0)                   KENNEY    62 HBC  -   1.2 PI-P
M-      130 (775.0)                   GUIRAGOSS 63 HBC  -   3.3 PI-P
M-  R       (768.0)    (5.0)          BLIEDEN   65 MMSP -   3-5 PI- P        6/66
M-           772.0     19.0           FIDECARO  66 OSPK -   2.5 PI-,T CUT18 11/66
M-  R       (760.0)    (5.0)          HAGOPIAN1 66 HBC  -   3.0 PI- P        6/66
M-  R       (770.0)    (5.0)          HAGOPIAN2 66 HBC  -   2.14 PI-P        9/67
M-  R       (765.0)    (5.0)          HAGOPIAN2 66 HBC  -   2.14 PI-,TCUT12  9/67
M-  R 6014  (757.6)    (6.6)          JACOBS    66 HBC  -   2-3PI-           6/68
M-  R 2775  (753.5)   (10.5)          JACOBS    66 HBC  -   2-3PI-,T CUT 20  6/68
M-  R       (749.0)    (3.0)          WEST      66 HBC  -   2.1 PI- P       10/66
M-           752.0     14.0           BANNER    67 MMS  -   1.8 PI-P,  P+MM  9/67
M-  C       (755.0)    (5.0)        3 BATON     67 HBC  -   2.8 PI- P       10/67
M-           751.       5.            CLEAR     67 HBC  -   3 PI- P          7/67
M-           764.       4.            EISNER    67 HBC  -   4.2 PI-P         9/67
M-  R       (777.0)    (6.0)          MILLER    67 HBC  -   2.7 PI-,T CUT 5  9/66
M-  R       (775.0)    (5.0)          MILLER    67 HBC  -   2.7 PI-,T CUT10  9/66
M-  R       (768.0)    (5.0)          MILLER    67 HBC  -   2.7 PI-,T CUT20  9/66
M-  R       (773.0)    (2.0)          BATON     68 HBC  -   2.8 PI-,T CUT13  7/69*
M-   12773   764.3      1.9      1.8 6 PISUT    68 RVUE -   1.7-3.2PI-,CT10  6/68
M-  A12773  (764.3)   (19.2)    (3.3 6 PISUT    68 RVUE -.  1.7-3.2PI-,CT10  6/68
M-  A   ERRORS ARE 2 STD AND INCLUDE SYSTEMATIC UNCERTAINTIES FROM THEORY
M-          . . . . . . . . . .
M-. AVG      762.8      2.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

MO  NEUTRAL ONLY
MO      190 (750.0)   (20.0)          SAMIOS    62 HBC .  0 4.7 PI-P
MO  R   300 (760.0)   (10.0)          ABOLINS   63 HBC    0 3.5 PI+P
MO      160 (775.0)                   GUIRAGOSS 63 HBC    0 3.3 PI-P
MO  R   500 (770.0)   (10.0)          GOLDHABER 64 HBC    0 3.7 PI+P
MO          (735.0)   (10.0)          ALYEA     65 DBC    0 2.2 K- P           6/66
MO          (750.0)                   CLARK     65 OSPK   0 1.5 PI-P
MO  J       (763.0)                   DERADO    65 DBC    0 4.0 PI- P          7/69*
MO  S       (750.0)   (15.0)          GUTAY     65 HBC    0 2.0 PI- P          6/66
MO           768.0     14.0           ACCENSI   66 HBC    0 5.7 PBARP          6/66
MO  R       (750.0)    (5.0)          ALFF-STEI 66 HBC    0 2-3 PI+ P          6/66
MO  S       (751.)     (6.)           BALTAY    66 HBC    0 0.0 PBARP          6/66
MO  P       (728.0)    (8.0)          CAMBRIDGE 66 HBC    0 1.0-6.0 GAMMA P   10/66
MO  S       (773.0)   (12.0)          CASON     66 HBC    0 7.0 PI- P          9/66
MO  R       (775.0)    (5.0)          HAGOPIAN1 66 HBC    0 3.0 PI- P          6/66
MO  R       (770.0)    (5.0)          HAGOPIAN2 66 HBC    0 2.14 PI-P          9/67
MO  R       (770.)     (5.)           HAGOPIAN2 66 HBC    0 2.1 PI-,TCUT 12    2/67
MO  R 7760  (763.3)    (6.0)          JACOBS    66 HBC    0 2-3PI-             6/68
MO  R 4207  (758.0)    (7.5)          JACOBS    66 HBC    0 2-3PI-,T CUT 20    6/68
MO  R       (765.0)    (8.0)          JAMES     66 HBC    0 2.1 PI+ P          6/66
MO  R       (760.0)    (3.0)          WEST      66 HBC    0 2.1 PI- P     .   10/66
MO           765.       5.            ASBURY 2  67 CNTR   0 GAMMA + PB         8/67
MO  B       (764.0)   (11.0)          AUSLANDER 67 OSPK   0 E+E- COLL.BEAMS   10/67
MO  B        AUSLANDER 68 IS UPDATING OF AUSLANDER 67
MO  R       (768.0)    (2.0)          BACON     67 HBC    0 1.7 PI-P           9/67
MO           745.       9.            BARLOW    67 HBC    0 1.2 PBAR P        11/66
MO      327  750.      10.            DANYSZ    67 HBC    0 3.0 PB P,6 PI      7/67
MO  W   184 (755.)     (5.)           DANYSZ    67 HBC    0 3.0 PB P,7 PI      7/67
MO  W        WIDTH UNUSUALLY SMALL, SEE BELOW UNDER WIDTH
MO  O   240 (752.)    (10.)           DANYSZ    67 HBC    0 3.0 PB P,7 PI      6/68
MO  O        SELECTION ON OMEGA.
MO  J       (781.)     (3.)           EISNER    67 HBC    0 4.2 PI-P           7/69*
MO  P       (728.0)    (6.0)          ERBE      67 HBC    0 3.5-5.8 GAMMA P   10/66
MO     1500  774.       3.            ERBE      67 HBC    0 1.4-5.8 GAMMA P    7/67
MO  R       (761.)     (3.)           HUWE      67 HBC    0 2.4 PI- P          7/67
MO  Q       (765.0)    (4.0)          MALAMUD   67 RVUE   0 PI+P,SEE NOTE Q    7/67
MO  Q       (767.0)    (2.0)        4 MALAMUD   67 RVUE   0 PI-P,SEE NOTE Q    7/67
MO  R       (770.0)    (4.0)          MILLER    67 HBC    0 2.7 PI-,T CUT20    9/66
MO          (777.0)    (5.0)          POIRIER   67 HBC    0 8.0 PI- P         11/67
MO           770.0      3.0           ABC COLL. 68 HBC    0 8 PI+P TO P+3PI    5/68
MO  R       (775.0)    (2.0)          ARMENISE  68 DBC    0 5.1 PI+D           6/68
MO          (762.0)    (7.0)          ARMENISE2 68 DBC    0 9.0 PI+ D          9/68
MO  E       (754.0)    (9.0)        2 AUSLANDER 68 OSPK   0 E+E- COLL.BEAMS    6/68
MO           SEE ALSO HAISSINSKI 69, WHO FITS AUSLENDER 68 DATA
MO           763.      15.            BLECHSCHM 68 HBC    0 GAMMA P (BREMS)    6/68
MO           745.0      5.0           DONALD    68 HBC    0 1.2 PB P,4 PR.     9/68
MO           776.       5.            FOSTER    68 HBC .  0 PBAR P AT REST     6/68
MO           775.0      3.0           HYAMS     68 OSPK   011.2 PI- P          9/68
MO  S       (765.0)    (6.0)          JONES     68 OSPK   0 12PI-, T LT 2.5    5/68
MO  S       (745.0)   (13.0)          JONES     68 OSPK   0 18PI-, T LT 2.5    5/68
MO  S       (760.0)    (9.0)          JONES     68 OSPK   0 18PI-,T2.5 TO 5    5/68
MO  S       (749.0)    (5.0)          JONES     68 OSPK   0 12PI-,T 5 TO 10    5/68
MO  S       (761.0)    (6.0)          JONES     68 OSPK   0 18PI-,T 5 TO 10    5/68
MO  S       (750.0)    (8.0)          JONES     68 OSPK   0 12PI-,T10 TO 15    5/68
MO  S       (780.0)   (10.0)          JONES     68 OSPK   0 18PI-,T10 TO 15    5/68
MO  S       (760.0)    (5.0)          KEY       68 HBC    0 3.0 PI- P          5/68
MO           766.       4.            LAMSA     68 HBC    0 8.0 PI-P          11/67
MO  P       (740.0)   (10.0)          LANZEROTT 68 CNTR   0 GAMMA P(BREMS)    10/66
MO  E       (770.0)    (4.0)          AUGUSTI1  69 OSPK   0 E+E- COLL.BEAMS    4/69*
MO           773.5      5.4         1 AUGUSTI2  69 OSPK   0 E+E- COLL.BEAMS    8/69*
MO           AUGUSTIN 2 TAKES ACCOUNT OF RHO-OMEGA INTERFERENCE, AND
MO           INCLUDES DATA OF AUGUSTIN 1.
MO  E       (768.)    (10.)           HAISSINSK 69 RVUE   0 E+E- COLL.BEAMS    9/69*
MO           HAISSINSKI 69 IS FIT TO AUSLENDER 68 DATA
MO  S       (755.0)   (15.0)          MOTT      69 HBC    0 4.1-5.5 K- P       7/69*
MO           770.0      5.0         7 ROOS      69 RVUE   0 E+E- COLL.BEAMS    9/69*
MO          . . . . . . . . . .
MO  AVG      769.0      2.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)

M   MIXED CHARGES
M       240 (752.0)                   ALITTI    63 HBC   -0 1.6 PI-P
M       290 (755.0)                   CHADWICK  63 HBC  +-0 0.0 PBAR P
M            744.       9.            FRENCH    67 HBC  +-0 3-4 PBAR P         6/67
M            775.0      2.0           JOHNSON   68 HBC   -0 3.7-4.2 PI- P      7/69*
M           . . . . . . . . . .
M   AVG      773.5      2.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M        ----------NOTES----------

M   C    FROM CHEW-LOW EXTRAPOLATION
M   E    INCLUDED IN ROOS 69 RVUE
M   J    INCLUDED IN JOHNSON 68
M   P    PHOTOPRODUCTION,UNCORRECTED FOR PRODUCTION E-DEPENDENCE
                                   OR BACKGROUND INTERFERENCE
M   Q    FROM PHASE SHIFT ANALYSIS
M   R    INCLUDED IN PISUT 68 RVUE
M   S    S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES

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        9  RHO(0) - RHO(+-) MASS DIFFERENCE (MEV)

D            2.4       2.1            PISUT     68 RVUE      PI N TO RHO N    6/68

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        9  RHO  WIDTH (MEV)

W        SEE NOTE ON RHO MASS ABOVE

W+  CHARGE PLUS ONLY
W+            90.0     10.0           SACLAY    63 HBC  +   2.8 PI+P
W+  R        (77.0)   (20.0)          CARMONY   64 HBC  +   3.5 PI+P,TCUT 4
W+           160.      10.            ARMENISE  65 HBC  +   2.8 PI+P
W+  R       (100.0)                   ALFF-STEI 66 HBC  +   2-3 PI+ P        6/66
W+  R       (177.0)   (15.0)          JAMES     66 HBC  +   2.1 PI+.P        7/66
W+  R       (147.0)   (19.0)          JAMES     66 HBC  +   2.1 PI+,TCUT2.5  8/66
W+           149.0     22.0           ABC COLL. 68 HBC  +   8 PI+P TO P+3PI  5/68
W+          . . . . . . . . . .
W+  AVG      127.2     24.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.6)

W+  CHARGE PLUS AND MINUS
W+  S       (150.0)   (30.0)          BALTAY    66 HBC  +-  0.0 PBARP        6/66
W+  S       (150.0)   (30.0)          BALTAY    66 HBC  +-  0.0 PBARP        6/66
W+           146.      31.            ALLES-BOR 67 HBC  +-  5.7 PBAR P      12/66
W+           130.      25.            BARLOW    67 HBC  +-  1.2 PBAR P      11/66
W+           145.      10.            FOSTER    68 HBC  +-  PBAR P AT REST   6/68
W+.         . . . . . . . . . .
W+  AVG      143.2      8.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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W-   CHARGE MINUS ONLY
W-      130 (125.0)                         GUIRAGOSS 63 HBC   -  3.3 PI-P
W-       98 (180.0)                         BONDAR    64 HBC   -  4.1 PI-P
W-   R      (127.0)     (5.0)               BLIEDEN   66 MMSP  -  3-5 PI- P         6/66
W-   R      (150.0)    (20.0)               HAGOPIAN1 66 HBC   -  3.0 PI- P         6/66
W-   R      (130.0)    (20.0)               HAGOPIAN2 66 HBC   -  2.14 PI-P         9/67
W-   R      (135.0)    (20.0)               HAGOPIAN2 66 HBC   -  2.14 PI-,TCUT12   9/67
W-   R 6014 (139.5)    (15.0)               JACOBS    66 HBC   -  2-3PI-            6/68
W-   R 2775 (137.1)    (20.0)               JACOBS    66 HBC   -  2-3PI-,T CUT 20   6/68
W-   R      (149.0)     (13.0)              WEST      66 HBC   -  2.1 PI- P        10/66
W-           100.0     30.0                 BANNER    67 MMS   -  1.8 PI-P,  P+MM   9/67
W-   C      (110.0)     (9.0)              3BATON     67 HBC   -  2.8 PI- P        10/67
W-           133.      11.                  EISNER    67 HBC   -  4.2 PI-P          9/67
W-   R      (137.0)    (17.0)               MILLER    67 HBC   -  2.7 PI-,T CUT 5   9/66
W-   R      (145.0)    (12.0)               MILLER    67 HBC   -  2.7 PI-,T CUT10   9/66
W-   R      (153.0)    (13.0)               MILLER    67 HBC   -  2.7 PI-,T CUT20   9/66
W-   R      (150.0)     (5.0)               BATON     68 HBC   -  2.8 PI- P         7/69*
W-    12773  147.3      4.0         3.9    6PISUT     68 RVUE  -  1.7-3.2PI-,CT10   6/68
W-           • • • • • • • • • •
W-   AVG     145.0      4.6        AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

WO   NEUTRAL ONLY
WO      190 (150.0)    (20.0)               SAMIOS    62 HBC    0 4.7 PI-P
WO   R  300  (90.0)    (10.0)               ABOLINS   63 HBC    0 3.5 PI+P
WO      160 (175.0)                         GUIRAGOSS 63 HBC    0 3.3 PI-P
WO   J   96 (210.0)                         BONDAR    64 HBC    0 4.1 PI-P          7/69*
WO   R  500 (130.0)                         GOLDHABER 64 HBC    0 3.7 PI+P
WO           110.0     20.0                 ALYEA     65 DBC    0 2.2 K- P          6/66
WO          (130.0)                         CLARK     65 OSPK   0 1.5 PI-P
WO   J      (150.0)                         DERADO    65 HBC    0 4.0 PI- P         7/69*
WO   S       (80.0)    (15.0)               GUTAY     65 HBC    0 2.0 PI- P         6/66
WO            72.0     30.0                 ACCENSI   66 HBC    0 5.7 PBARP         6/66
WO   R      (100.0)                         ALFF-STEI 66 HBC    0 2-3 PI+ P         6/66
WO   S      (174.)     (31.)                BALTAY    66 HBC    0 0.0 PBARP         6/66
WO   P      (175.0)                         CAMBRIDGE 66 HBC    0 5-6 GAM P         9/66
WO   S       (57.0)    (25.0)    (15.0)     CASON     66 HBC    0 7.0 PI- P         9/66
WO   R      (120.0)    (10.0)               HAGOPIAN1 66 HBC    0 3.0 PI- P         6/66
WO   R      (130.0)    (20.0)               HAGOPIAN2 66 HBC    0 2.14 PI-P         9/67
WO   R      (135.0)    (20.0)               HAGOPIAN2 66 HBC    0 2.14 PI-P,LOW T   9/67
WO   R 7760 (136.4)    (12.0)               JACOBS    66 HBC    0 2-3PI-            6/68
WO   R 4207 (122.2)    (15.0)               JACOBS    66 HBC    0 2-3PI-,T CUT 20   6/68
WO   R      (103.0)    (13.0)               JAMES     66 HBC    0 2.1 PI+ P         6/66
WO   R      (173.0)    (13.0)               WEST      66 HBC    0 2.1 PI- P        10/66
WO           130.       5.                  ASBURY 2  67 CNTR   0 GAMMA + PB        8/67
WO   B       (93.0)    (15.0)               AUSLANDER 67 OSPK   0 E+ E- COLLID.BM  10/67
WO   B       AUSLANDER 68 IS UPDATING OF AUSLANDER 67
WO   R      (148.0)     (8.0)               BACON     67 HBC    0 1.7 PI-P          9/67
WO            92.      42.                  BARLOW    67 HBC    0 1.2 PBAR P       11/66
WO      327  135.      25.                  DANYSZ    67 HBC    0 3.0 PB P,6 PI     7/67
WO   W  184  (28.)     (15.)                DANYSZ    67 HBC    0 3.0 PB P,7 PI     7/67
WO   W          WIDTH UNUSUALLY SMALL
WO   O  240  (80.)     (30.)                DANYSZ    67 HBC    0 3.0 PB P,7 PI     6/68
WO   O          SELECTION CN CMEGA
WO   J      (166.)     (11.)                EISNER    67 HBC    0 4.2 PI-P          7/69*
WO   R      (152.)     (15.)                HUWE      67 HBC    0 2.4 PI- P         7/67
WO   M      (149.0)     (5.0)              4MALAMUD   67 RVUE   0 PI-P              7/67
WO   M      (154.0)     (8.0)               MALAMUD   67 RVUE   0 PI+P              7/67
WO   M       SCHLEIN 68 IS UPDATING OF MALAMUD 67
WO   R      (160.0)    (15.0)               MILLER    67 HBC    0 2.7 PI-,T CUT20   9/66
WO          (135.0)    (10.0)               POIRIER   67 HBC    0 8.0 PI- P        11/67
WO           165.0     10.0                 ABC COLL. 68 HBC    0 8 PI+P TO P+3PI   5/68
WO   R      (167.0)     (6.0)               ARMENISE  68 DBC    0 5.1 PI+D          6/68
WO          (170.0)    (10.0)               ARMENISE2 68 DBC    0 9.0 PI+ D         9/68
WO   E      (105.0)    (20.0)              2AUSLANDER 68 OSPK   0 E+E- COLL.BEAMS   6/68
WO           SEE ALSO HAISSINSKI 69, WHO FITS AUSLENDER 68 DATA
WO           126.      20.                  BLECHSCHM 68 HBC    0 GAMMA P (BREMS)   6/68
WO           150.0     13.0                 DONALD    68 HBC    0 1.2 PB P,4 PR.    9/68
WO           132.      10.                  FOSTER    68 HBC    0 PBAR P AT REST    6/68
WO           145.0      9.0                 HYAMS     68 OSPK   011.2 PI- P         9/68
WO   S      (129.0)    (19.0)               JONES     68 OSPK   0 12PI-, T LT 2.5   5/68
WO   S      (169.0)    (41.0)               JONES     68 OSPK   0 18PI-, T LT 2.5   5/68
WO   S      (175.0)    (30.0)               JONES     68 OSPK   0 18PI-,T2.5 TO 5   5/68
WO   S      (157.0)    (16.0)               JONES     68 OSPK   0 12PI-,T 5 TO 10   5/68
WO   S      (157.0)    (19.0)               JONES     68 OSPK   0 18PI-,T 5 TO 10   5/68
WO   S      (102.0)    (25.0)               JONES     68 OSPK   0 12PI-,T10 TO 15   5/68
WO   S      (157.0)    (31.0)               JONES     68 OSPK   0 18PI-,T10 TO 15   5/68
WO   S      (113.0)    (16.0)               KEY       68 HBC    0 3.0 PI- P         5/68
WO           111.       8.                  LAMSA     68 HBC    0 8.0 PI-P         11/67
WO   S      (160.0)    (10.0)               LANZEROTT 68 CNTR   0 GAMMA P           5/68
WO   C14890 (105.0)    (15.0)              5MARATECK  68 HBC    0 1.9-3.0 PI- P     9/68
WO   O      (135.0)    (10.0)              8SCHLEIN   68 RVUE   01.6,4.,8.PI- P     9/68
WO           122.0      7.0         6.0    7ROOS      69 RVUE   0 E+E- COLL.BEAMS   9/69*
WO   E      (111.0)     (6.0)               AUGUSTI1  69 OSPK   0 E+E- COLL.BEAMS   4/69*
WO           110.7      5.3                1AUGUSTI2  69 OSPK   0 E+E- COLL.BEAMS   8/69*
WO           AUGUSTIN 2 TAKES ACCOUNT OF RHO-OMEGA INTERFERENCE, AND
WO           INCLUDES DATA OF AUGUSTIN 1.
WO   E      (140.)     (14.)                HAISSINSK 69 RVUE   0 E+E- COLL.BEAMS   9/69*
WO   H       ABOVE VALUE FROM FIT TO AUSLENDER 68 DATA
WO   S      (130.0)    (40.0)               MOTT      69 HBC    0 4.1-5.5 K- P      7/69*
WO           • • • • • • • • • •
WO   AVG     126.0      4.8        AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9)

W    MIXED CHARGES
W       290 (110.0)                         CHADWICK  63 HBC  +-0 0.0 PBAR P
W            98.       30.                  FRENCH    67 HBC  +-0 3-4 PBAR P        6/67
W           154.0       6.0                 JOHNSON   68 HBC   -0 3.7-4.2 PI- P     7/69*
W            • • • • • • • • • •
W    AVG     151.8      5.9        AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W         ----------NOTES----------

W    C  FROM CHEW-LOW EXTRAPOLATION
W    E  INCLUDED IN ROOS 69 RVUE
W    J  INCLUDED IN JOHNSON 68
W    R  INCLUDED IN PISUT 68 RVUE
W    P  PHOTOPRODUCTION, UNCORRECTED (SEE NCTE P UNDER RHO MASS)
W    O  FROM PHASE SHIFT ANALYSIS
W    S  S-WAVE BREIT-WIGNER FIT, CANNOT BE COMBINED WITH OTHER VALUES
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                    9  RHO PARTIAL DECAY MODES

                                                             DECAY MASSES
P1     RHO INTO 2PI                                          139+ 139
P2     RHO INTO 4PI                                          139+ 139+ 139+ 139
P3     RHO INTO PI GAMMA                                     139+   0
P4     RHO INTO E+ E-                                         .5+  .5
P5     RHO INTO PI ETA (VIOLATES G)                          139+ 548
P6     RHO INTO MU+ MU-                                      105+ 105
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                      9  RHO BRANCHING RATIOS

R1     RHO INTO 4PI/2PI

R1     RHO+- INTO (PI+- PI+ PI- PI0) / (PI+- PI0)
R1          (0.026)OR LESS          BLIEDEN   66 MMSP  -   3-5 PI- P            6/66
R1          (0.01)OR LESS           DEUTSCHMA 66 HBC   +   8.0 PI+ P            6/66
R1          (0.002)OR LESS          FERBEL    66 HBC   +- PI+- P ABOVE 2.5    10/66
R1           0.0035    0.004        JAMES     66 HBC   +   2.1 PI+P            11/66

R1     RHO 0 INTO (PI+ PI- PI+ PI-) / (PI+ PI-)
R1          (0.008)OR LESS          JAMES     66 HBC    0 2.1 PI+P              6/66
R1          (0.0015) OR LESS,CL=0.90 LOHRMANN 67 HBC    0 2.5-5.8 GAMMA P     10/67
R1          (0.002)OR LESS          CHUNG     68 HBC    0 3.2,4.2 PI-P          7/67

R2     RHO INTO PI GAMMA/2PI
R2  M       (0.02)OR LESS           LANZEROTT 65 CNTR     GAMMA P(BREMS)      11/66
R2          (0.005)OR LESS          FIDECARO  66 OSPK  -  0.97 CONF LEV       10/66
R2          (0.007)OR LESS          HUSON     66 HLBC  -  15 PI-PB             6/66
R2  M       (0.004)OR LESS          ERBE      67 HBC   -  3.5-5.5 GAMMA P     10/66
R2  M       ERBE 67 SUPERSEDED BY GERMAN COLL. BELOW
R2  M       (0.002)OR LESS          GERMAN CO 69 HBC   -  3.5-5.5 GAMMA P      9/69*
R2  M       ONE PION EXCHANGE MODEL USED IN THIS ESTIMATION

R3     RHO INTO(E+ E-)/(PI+PI-)     (UNITS 10**-4)
R3  P       SEE NOTE P ON LEPTONIC DECAY MODES BELOW
R3      94   0.65     0.14          ASBURY 1  67 CNTR     PHOTOPRODUCTION      9/67
R3  T       ASBURY 1 HAS MASS RESOLUTION OF +-15 MEV.
R3  B       (0.49)   (0.08)         AUSLANDER 67 OSPK     E+E- COLLID.BEAM    10/67
R3  B       FROM SIGMA(RHO)=1.2+-0.2 MICROBARNS. SEE HEIDELB.CONF. P.353
R3  B       AUSLANDER 68 IS UPDATING OF AUSLANDER 67
R3  H       (0.65)   (1.1)    (0.5) HERTZBACH 67 OSPK ASSUME SU(3)+MIXING 10/66
R3  H       NOT SEPARATED FROM OMEGA DECAY.
R3  A   33  (0.53)   (0.11)         ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R3  A       NOT SEPARATED FROM OMEGA DECAY. ERROR STATISTICAL ONLY.
R3           0.50     0.10          AUSLANDER 68 OSPK     E+E- COLLID.BEAM     9/68
R3           0.663    0.085         AUGUSTI1  69 OSPK     SEE NOTE E           4/69*
R3  E       FROM E+ E- COLL. BEAMS, ASSUMING RHO WIDTH 111 MEV
R3           • • • • • • • • •
R3  AVG      0.604    0.059    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4     RHO INTO (PI ETA)/(2PI)
R4          (0.03)OR LESS           DEUTSCHMA 66 HBC   +   8.0 PI+ P            6/66
R4          (0.008) OR LESS         FERBEL    66 HBC   +- PI+- P ABOVE 2.5    11/66

R5     RHO INTO (MU+ MU-)/(PI+ PI-) (UN 10**-4)
R5  P       SEE NOTE P ON LEPTONIC DECAY MODES BELOW
R5         (14.0)OR LESS            HERTZBACH 67 OSPK     3.0 PI-P            10/66
R5           0.97     0.31    0.33  HYAMS     67 OSPK    11 PI- LI H           6/67
R5  H       HYAMS MASS RESOL. IS 20 MEV. THE OMEGA REGION WAS EXCLUDED.
R5           0.59     0.15    0.26  WEINSTEIN 67 CNTR     PHOTOPRODUCTION     10/67
R5  C       SEE DAVIER 68 AND PARSONS 68 FOR POSSIBLE CORRECTIONS OF       9/69*
R5  C       UP TO 60 PERCENT FOR OMEGA-RHO INTERFERENCE. WE THEREFORE      9/69*
R5  C       INCREASED THE -ERROR ON WEINSTEIN 67.                          9/69*
R5           0.56     0.15          WEHMANN   69 OSPK    12 PI- ON C,FE        7/69*
R5  W       RESULT CONTAINS (11 +- 11) PER CENT CORRECTION USING SU(3)
R5  W       FOR CENTRAL VALUE. THE ERROR ON THE CORRECTION TAKES ACCOUNT
R5  W       OF POSSIBLE RHO-OMEGA INTERFERENCE AND THE UPPER LIMIT AGREES
R5  W       WITH THE UPPER LIMIT OF (OMEGA INTO MU+ MU-) FROM THIS EXPT.
R5           • • • • • • • • •
R5  AVG      0.62     0.11     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R
R   P   ---------- NOTE P ON LEPTONIC DECAY MODES ----------
R   P   IN EXTRACTING THE BRANCHING RATIOS, THE POSSIBILITY OF INTERFERENCE
R   P   WITH LEPTONIC DECAYS OF THE OMEGA HAS TO BE TAKEN INTO ACCOUNT.

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REFERENCES FOR RHO


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ANDERSON 61 PRL 6 365         ANDERSON,BANG,BURKE,CARMONY,SCHMITZ  (LRL)
KENNEY   62 PR 126 736        V P KENNEY,W D SHEPHARD,C D GALL (KENTUCKY)
SAMIOS   62 PRL 9 139         SAMIOS,BACHMAN,LEA+  (BNL+CCNY+COLUM+KENT)
XUONG    62 PR 128 1849       NGUYEN HUU XUONG,GERALD R LYNCH      (LRL)

ABOLINS  63 PRL 11 381        ABOLINS,LANDER,MEHLHOP,NGUYEN,YAGER (UCSD)
ALITTI   63 NC 29 515         ALITTI,BATON,ARMENISE+(SAC+ORSAY+BARI+BOLO)
CHADWICK 63 PRL 10 62         CHADWICK,DAVIES,DERRICK,CRESTI + (OXF+PAD)
GUIRAGOS 63 PRL 11 85         ZAVEN GUIRAGOSSIAN                   (LRL)
SACLAY   63 SIENA CONF 1 239  SACLAY+ORSAY+BARI + BOLOGNA(COLLABORATION)

BATON    64 NC 35 713         BATON,BERTHELOT,ALLES,BORELLI + (CEN+BOLOG)
BONDAR   64 NC 31 729         BONDAR+ (AACHEN+BIRM+BONN+DESY+IMP-COL+MPI)
CARMONY  64 DUBNA CONF 1 486  CARMONY,HCA,LANCER,NG.H.XUONG,YAGER  (UCSD)
GOLDHABE 64 PRL 12 336        GOLDHABER,BROWN,KADYK,SHEN,TRILLING(LRL+UC)

ALYEA    65 PL 15 82          ALYEA,CRITTENDEN,MARTIN,RHODE +    (INDIANA)
ARMENISE 65 NC 37 361         SACLAY+ORSAY+BARI+BOLOGNA (COLLABORATION )
BLIEDEN  65 PL 19 444         CERN MISSING MASS SPECTROMETER GROUP (CERN)
CLARK    65 PR 139 B 1556     A CLARK,CHRISTENSON,CRONIN,TURLAY(PRINCETO)
DERADO   65 PRL 14 872        DERADO,KENNEY,POIRIER,SHEPHARD (NOTRE DAME)
GUTAY    65 NC 39 381         GUTAY,LANNUTTI,TULI                (FLORIDA)
LANZEROT 65 PRL 15 210        LANZEROTTI,BLUMENTHAL,EHN,FAISSLER +(HARVD)
WOLF     65 PL 19 328         G WOLF                                (DESY)
ZDANIS   65 PRL 14 721        ZDANIS,MADANSKY,KRAEMER +          (JHU+BNL)

ACCENSI  66 PL 20 557         ACCENSI,ALLES-BORELLI,FRENCH,FRISK+ (CERN)
ALFF-STE 66 PR 145 1072       ALFF-STEINBERGER,BERLEY,BRUGGER+ (COL+RUTG)
BALTAY   66 PR 145 1103       +FRANZINI,LUTJENS,SEVERINS,TYCKC+(COLUMBIA)
BLIEDEN  66 NC 43 71          CERN MISSING MASS SPECTROMETER GROUP (CERN)
CAMBRIDG 66 PR 146 994        CAMBRIDGE BUBBLE CHAMBER GROUP (MIT+HARV+)
CASON    66 PR 148 1282       N M CASON                        (WISCONSIN)
DEUTSCHM 66 PL 20 82          DEUTSCHMANN,STEINBERG + (AACH+BERLIN+ CERN)
FERBEL   66 PL 21 111         FERBEL                           (ROCHESTER)
FIDECARO 66 PL 23 163         G+M FIDECARO,J POIRIER,P SCHIAVON   (CERN)
HAGOPIA1 66 PR 145 1128       HAGOPIAN,SELOVE,ALITTI,BATON+ (PENN+SACLAY)
HAGOPIA2 66 PR 152 1183       HAGOPIAN,PAN    (PENNSYLVANIA,LRL-BERKELEY)
HUSON    66 PL 20 91          HUSON,ALLARD,DRIJARD,HENNESSY + (ORSAY+EP)
JACOBS   66 UCRL-16877        L.D.JACOBS                           (LRL)
JAMES    66 PR 142 896        F E JAMES,KRAYBILL          (YALE+BROOKHAVEN)
WEST     66 PR 149 1089       WEST,BOYD,ERWIN,WALKER           (WISCONSIN)

ALLES-BO 67 NC 50 A 776       ALLES-BORELLI,FRENCH,FRISK,+     (CERN+BONN)
ASBURY 1 67 PRL 19 869        +BECKER+BERTRAM+JOOS+JORDAN+TING+(DESY+COL)
ASBURY 2 67 PRL 19 865        +BECKER+BERTRAM+JOOS+JORDAN+TING+(DESY+COL)
AUSLANDE 67 PL 25 B 433       AUSLANDER,BUDKER,PESTOV,SIDOROV+(NCVOSIBIR)
BACON    67 PR 157 1263       +FICKINGER,HILL,HOPKINS,ROBINSON+      (BNL)
BANNER   67 PL 25 B 300       +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BARLOW   67 NC 50A 701        +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
BATON    67 PL 25 B 419       J.BATON,G.LAURENS,J.REIGNIER        (SACLAY)
    ALSO 67 NP B 3 349        J.BATON,G.LAURENS,J.REIGNIER        (SACLAY)
CLEAR    67 NC 49A 399        +JOHNSTON+COOPER+MANNER+WALKER+(TO+ANL+WIS)
DANYSZ   67 NC 51 A 801       DANYSZ+FRENCH+SIMAK                   (CERN)
EISNER   67 PR 164 1699       +JOHNSON+KLEIN+PETERS+SAHNI+YEN+    (PURDUE)
ERBE     67 NC 48A 262        +BOTTCHER+MOEBES+HARIGEL+LUKE+    (ABBDHHM)
FRENCH   67 NC 52A 442        +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)
HERTZBAC 67 PR 155 1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
    (SEE ALSO ZDANIS 65)
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Data in parentheses have not been included in our averages.

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HUWE     67 PL 24B 252           +MARQUIT+OPPENHEIMER+SCHULTZ+WILSON   (COL)
HYAMS    67 PL 24B 634           +KOCH+PELLETT+POTTER+VONLINDERN+ (CERN+MUN)
LOHRMANN 67 SLAC SYMP.P. 199     +HILPERT+ (AACH+BERL+BONN+HAMB+HEID+MUNICH)
MALAMUD  67 PRL 19 1056          E.MALAMUD+P.E.SCHLEIN                (UCLA)
    SEE ALSO MALAMUD 69
MILLER   67 PR 153 1423          MILLER,GUTAY,JOHNSON,LOEFFLER +    (PURDUE)
POIRIER  67 PR 163 1462          +BISWAS,CASON,DERADO,KENNEY+ (NOTRDAM+PENN)
WEHMANN  69 PR 178 2095          +ENGELS,WILSON,+ (HARV+CASE+SLAC+CORN+MCGI)
WEINSTEI 67 SLAC SYMPOS.P.424 R.WEINSTEIN,RAP.TALK      (CEA+NORTHEASTERN)

ABC COLL 68 NP B4 501                     (AACHEN+BERLIN+CERN COLLABORATION)
ARMENISE 68 NC 54A 999           +GHIDINI,FORINO+ (BARI+BOLOGN+FIRENZ+ORSAY)
ARMENIS2 68  VIENNA CONF. 412 ARMENISE,FORINO,CARTACCI+  (BARI+BGNA+FIRZ)
ASTVACAT 68 PL 27 B  45          ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
AUSLANDE 68  NOVOSIB.PRE. 243 AUSLANDER,BUDKER,PAHTUSOVA,PESTOV+    (NOVO)
   (SEE ALSO AUSLANDER 67)
BATON    68 PR 176 1574          J.P. BATON, G. LAURENS               (SACLAY)
BLECHSCH 68 NC  53 A  1045       BLECHSCHMIDT,DOWD,ELSNER,+     (DESY+MANCH)
  (SEE ALSO NC  52 A  1348 )
CHUNG    68 PR 165 1491          S.U.CHUNG,O.I.DAHL,J.KIRZ,D.H.MILLER  (LRL)
DAVIER   68 PL  27 B  27         M. DAVIER                            (SLAC)
DONALD   68 NP B 6 174           +EDWARDS,FRODESEN,BETTINI+ (LIVP+OSLO+PADO)
FOSTER   68 NP B 6 107           +GAVILLET+LABROSSE+MONTANET+    (CERN+PARIS)
HYAMS    68 NP B 7 1             +KOCH,POTTER,WILSON,VON LINDERN+(CERN+MPIM)
JONES    68 PR 166 1405          +BLEULER,CALDWELL,ELSNER,HARTING+    (CERN)
JOHNSON  68 PR 176 1651          +POIRIER,BISWAS,GUTAY,DERADO+(ND+PURD+SLAC)
KEY      68 PR 166 1430          +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)
LAMSA    68 PR 166 1395          +CASON+BISWAS+DERADO+GROVES+   (NOTREDAME)
LANZEROT 68 PR 166 1365          LANZEROTTI,BLUMENTHAL,EHN,FAISSLER +(HARVD)
MARATECK 68 PRL 21 1613          +HAGOPIAN,+  (PENN+LRL+COLO+PURD+TNTO+WISC)
PARSONS  68 PRL  20  1314        RONALD E. PARSONS, ROY WEINSTEIN(NORTHEAST)
PISUT    68 NP B 6 325           J.PISUT,M.ROOS                       (CERN)
SCHLEIN  68 PHILA.CONF P 161     PETER E. SCHLEIN                     (UCLA)
   SEE ALSO MALAMUD 69

AUGUSTI1 69 PL 28 B 508          +BIZOT+BUON+HAISSINSKI+LALANNE+     (ORSAY)
AUGUSTI2 69 LNC 2 214            +LEFRANCOIS,LEHMANN,MARIN,+         (ORSAY)
GERMAN C 69  DESY 69/19          GERMAN BUBBLE CHAMBER COLL.          (DESY)
HAISSINS 69  ARGONNE CONF.       J.HAISSINSKI                        (ORSAY)
MALAMUD  69  ARGONNE CONF        + P. SCHLEIN, PREPRINT NAL-29(2050)  (UCLA)
MILLER   69 PR 178 2061          R.MILLER,LICHTMAN,WILLMANN         (PURDUE)
MOTT     69 PR 177 1966          +AMMAR,DAVIS,KROPAC,SLATE,DAGAN+ (NWES+ANL)
ROOS     69 NP B 10 563          M.ROOS,J.PISUT          (CERN+BRATISLAVA)
WEHMANN  69 PR 178  2095         +ENGELS,WILSON,+ (HARV+CASE+SLAC+CORN+MCGI)

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ω(784)

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1  OMEGA (784,JPG=1--)  I=0
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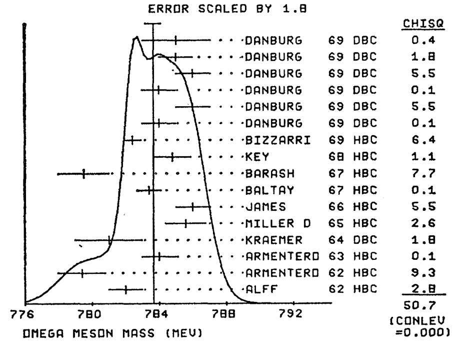
                  1  OMEGA  MASS (MEV)

M      400  782.0     1.0           ALFF      62 HBC     2.3-2.9 PI+P
M       64  779.4     1.4           ARMENTERO 62 HBC     0.0 PBAR P
M       34  784.0     1.0           ARMENTEPO 63 HBC     0.0 PBAR P
M      220  781.0     2.0           KRAEMER   64 DBC     1.2 PI+D
M           785.6     1.2           MILLER D  65 HBC    SEEN WITH K+K-
M      666  786.0     1.0           JAMES     66 HBC     2.1 PI+P          6/66
M     2198  783.4     0.7           BALTAY    67 HBC    0.0 PBAR P         9/66
M      155  779.5     1.5           BARASH    67 HBC    0 PBAR TO K1K1OM  11/66
M           784.8     1.1           KEY       68 HBC     3 PI-P           11/67
M     2400  782.4     0.5           BIZZARRI  69 HBC     0 PBAR P          9/69*
M      250  784.      1.            DANBURG   69 DBC     1.2 PI+ D         9/69*
M      500  786.      1.            DANBURG   69 DBC     1.4 PI+ D         9/69*
M      600  784.      1.            DANBURG   69 DBC     1.7 PI+ D         9/69*
M      500  786.      1.            DANBURG   69 DBC     1.9 PI+ D         9/69*
M      400  785.      1.            DANBURG   69 DBC     2.1 PI+ D         9/69*
M      200  785.      2.            DANBURG   69 DBC     2.3 PI+ D         9/69*
M
M   AVG     783.67    0.45    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)
                      (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 783.67 ± 0.45
ERROR SCALED BY 1.8

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                  1  OMEGA FULL WIDTH (MEV)

W       34    9.0      3.0          ARMENTERO 63 HBC      0.0 PBAR P
W             13.4     2.0          MILLER D  65 HBC    SEEN WITH K+ K-
W      666   (20.0)  OR LESS        JAMES     66 HBC      2.1 PI+P          6/66
W      155    12.3     2.0          BARASH    67 HBC     SEEN WITH K1 K1    6/66
W             16.2     3.2          AUGUSTI1  69 OSPK    E+ E- COLL.BEAMS   4/69*
W
W   AVG       12.7     1.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
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                  1  OMEGA PARTIAL DECAY MODES

                                                              DECAY MASSES
P1    OMEGA INTO PI+ PI- PIO                                 139+ 139+ 134
P2    OMEGA INTO PI+ PI- (VIOLATES G)                        139+ 139
P3    OMEGA INTO PIO GAMMA (ONLY NEUTRAL INPUT TO FIT)       134+   0
P4    OMEGA INTO PI+ PI- GAMMA                               139+ 139+   0
P5    OMEGA INTO 2PIO GAMMA                                  134+ 134+   0
P6    OMEGA INTO ETA GAMMA                                   548+   0
P7    OMEGA INTO E+ E-                                        .5+  .5
P8    OMEGA INTO MU+ MU-                                     105+ 105
P9    OMEGA INTO ETA PIO (VIOLATES C)                        548+ 134
P10   OMEGA INTO 3 GAMMA                                      0+   0+    0
P11   OMEGA INTO PIO MU+ MU-                                 134+ 105+ 105
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                  1  OMEGA  BRANCHING RATIOS
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Note on the branching ratios of ω(784)

Note that the errors of the decay branching ratios in the Meson Table are slightly different from their values below (under "VALUE FROM CONSTRAINED FIT"), the table values being more conservative. The CONSTRAINED FIT only takes into account the decay modes $\pi^+\pi^-\pi^0$, $\pi^+\pi^-$, and neutrals, the latter defined as $\pi^0\gamma$. In the Meson Table we have also taken into account the upper limits, L_i (one-standard-deviation values), on the $\eta\gamma$, $\pi^+\pi^-\gamma$, and $\pi^0\pi^0\gamma$ decays by treating them as if they were measurement results of value $0 \pm L_i$.

```
R1    OMEGA INTO NEUTRAL/(PI+ PI- PIO)
R1          0.17      0.04             ARMENTERO 63 HBC      0.0 PBAR P
R1     20   0.11      0.02             BUSCHBECK 63 HBC      1.5 K-P
R1     35   0.08      0.03             KRAEMER   64 DBC      1.2 PI+D
R1     65   0.10      0.04             ALFF-STEI 66 HBC CORR.BY SCHULTZ(COL)  9/66
R1    850   0.134     0.026            DIGIUGNO  66 CNTR     1.4 PI-P         9/66
R1    348   0.097     0.016            FLATTE    66 HBC      1.8 K-P          9/66
R1          0.06      0.05     0.02    JAMES     66 HBC      2.1 PI+P         6/66
R1     19   0.10      0.03             BARASH    67 HBC      0.0 PBAR P       7/67
R1
R1  AVG     0.1043    0.0091  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT     0.1077    0.0077   VALUE FROM CONSTRAINED FIT

R2    OMEGA INTO (PI+ PI-)/(PI+ PI- PIO).  SEE ALSO R12
R2         (0.010)OR LESS              BUTTON    62 HBC      1.6 PBAR P
R2         (0.07)                      ALITTI    63 HBC      1.6 PI-P
R2         (0.05) OR LESS              ARMENTERO 63 HBC      0.0 PBAR P
R2    100  (0.05) OR GREATER           FICKINGER 63 HBC      1.7 PI-P
R2         (0.05) OR LESS              KRAEMER   64 DBC      1.2 PI+D
R2         (0.005)OR LESS              LUTJENS   64 RVUE NO INTERFERENCE
R2         (0.018)  (0.012)  (0.006)WALKER     64 RVUE      2.1 PI-P
R2         (0.04) OR GREATER           BATON     65 HBC      2.8 PI-P
R2         (0.010)OR LESS              CLARK     65 OSPK     1.5 PI-P         6/66
R2         (0.035)OR LESS              MILLER D  65 HBC
R2         (0.02) OR LESS              ALFF-STEI 66 HBC      2.9 PI+P        11/66
R2         (0.029)  (0.011)  (0.009)FLATTE     66 HBC  INTERFERENCE          9/66
R2         (0.082)  (0.020)            FLATTE    66 HBC  NO INTERFERENCE       9/66
R2          FLATTE 66 SUPERSEDED BY FLATTE 69 BELOW
R2         (0.013)OR LESS              ROOS      67 RVUE     2-4 PI+P,P 3PI   9/69*
R2         (.002)OR MORE.90 PCT CONFFLATTE    69 HBC     1.2-2.7 K- P      8/69*
R2          NOT ESTABLISHED WHETHER ANY PI+PI- SIGNAL HAS I=0(PISUT 68)
R2
R2  FIT     0.036     0.026    VALUE FROM CONSTRAINED FIT

R3    OMEGA INTO (PIO GAMMA) / (PI+ PI- PIO)
R3         (0.125)  (0.025)OR GRTR. BARMIN    64 PXBC     2.8 PI-P
R3          0.13      0.04             JACQUET   67 HLBC                     10/67
R3
R3  FIT     0.1077    0.0077   VALUE FROM CONSTRAINED FIT

R4    OMEGA INTO (PI+ PI- GAMMA)/(PI+ PI- PIO)
R4         (0.05)  OR LESS             FLATTE    66 HBC      1.8 K-P          9/66

R6    OMEGA INTO (MU+ MU-)/(PI+ PI- PIO)(UNITS 10**-3)
R6         (1.2)  OR LESS              GALTIERI  65 HBC      2.7 K-P
R6         (1.7)OR LESS                FLATTE    66 HBC      1.8 K-P          9/66
R6         (0.2)  OR LESS              WILSON    69 OSPK     12 PI- ON C,FE   9/69*

R7    OMEGA INTO (2PIO GAMM)/(PIO GAMMA)
R7         (0.1)  OR LESS              BARMIN    64 PXBC     1.3-2.8 PI-P
R7         (0.45)   (0.33)             STRUGALSK 69 HLBC     2.34 PI+ N       8/69*

R8    OMEGA INTO(ETA PIO +ETA GAM)/(PI+PI-PIO)
R8         (0.017) OR LESS             FLATTE    66 HBC      1.8 K-P          9/66
R8         (0.026)OR LESS              JACQUET   67 HLBC    CL=0.90          10/67

R9    OMEGA INTO (NEUTRALS) / (CHARGED)
R9          0.124     0.021            FELDMAN   67 OSPK     1.2 PI- P        3/67
R9
R9  FIT     0.1039    0.0076   VALUE FROM CONSTRAINED FIT

R10   OMEGA INTO (2PIO GAMMA)/(PI+PI-PIO)
R10        (0.1)  OR LESS              JACQUET   67 HLBC    CL=0.90          10/67

R11   OMEGA INTO (ETA GAMMA)/(PIO GAMMA)
R11        (0.58)   (0.30)             STRUGALSK 69 HLBC     2.34 PI+ N       8/69*

R12   OMEGA INTO (PIO MU+ MU-) / TOTAL  (UNITS 10**-3)
R12        (2.)   OR LESS              WEHMANN   68 OSPK    12 PI- FE         6/68
```

Data in parentheses have not been included in our averages.

```
R13     OMEGA INTO (E+ E-)/TOTAL    (UNITS 10**-4)
R13       3    2.       1.2            BINNIE    65 OSPK     PI-P NEAR THLD.  6/66
R13 B          MASS RESOLUTION OF BINNIE 65 IS ABOUT 15 MEV.
R13 H         (1.0)    (1.7)    (0.75) HERTZBACH 67 OSPK ASSUME SU(3)+MIXING 10/66
R13 H          NOT RESOLVED  FROM RHO DECAY.
R13 A    33   (0.65)   (0.13)          ASTVACATU 68 OSPK ASSUME SU(3)+MIXING  6/68
R13 A          NOT RESOLVED  FROM  RHO  DECAY. ERROR STATISTICAL ONLY.
R13            0.40     0.21           BOLLINI 1 68 CNTR     1.7PI-P,NOTE Z   9/68
R13 Z          MASS RESOLUTION OF BOLLINI 1 IS +-10 MEV.HIS ERROR IS +-.15
R13 Z          WITHOUT RHO-OMEGA INTERFERENCE. COMPLETE INTERFERENCE WOULD
R13 Z          CHANGE VALUE BY +-35 PER CENT. THEREFORE WE INCREASED ERROR.
R13            0.76     0.14           AUGUSTI1  69 OSPK     SEE NOTE E       9/68
R13 E   FROM E+ E- COLLIDING BEAMS, ASSUMING OMEGA WIDTH 12.2+-1.3 MEV        4/69*
R13          . . . . . . . . . .
R13 AVG        0.66     0.17    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

R14     OMEGA INTO NEUTRALS / TOTAL
R14            0.084    0.015          BOLLINI   68 CNTR    2.1 PI- P         6/68
R14           (0.079)  (0.019)         KARLSRUHE 69 OSPK                      9/69*
R14          . . . . . . . . .
R14 FIT        0.0941   0.0062   VALUE FROM CONSTRAINED FIT

R15     OMEGA INTO (PI PI)/(TOTAL). SEE ALSO R2
R15            0.032    0.028    0.019 AUGUSTI2  69 OSPK     E+E- COLL.BEAMS  8/69*
R15 A          AUGUSTIN 68 GIVES SQUARE ROOT OF PARTIAL WIDTH,FOR DECAY       9/69*
R15 A          INTO (PI PI),AS (0.63+-0.23)(MEV)**1/2.THEY ASSUME TOTAL       9/69*
R15 A          OMEGA WIDTH AS 12.2+-1.3 MEV.FROM THIS WE CALCULATED THE       9/69*
R15 A          BRANCHING RATIO GIVEN ABOVE.
R15        0.003 OR MORE, 95 PCT.CONF.ALEXANDER 69 HBC     1.7-2.7 K-P       11/69*
R15         . . . . . . . . . . .
R15 FIT        0.031    0.022    VALUE FROM CONSTRAINED FIT

R16     OMEGA INTO  (ETA GAMMA) / (ALL NEUTRALS)
R16           (0.24) OR LESS           KARLSRUHE 69 OSPK                      9/69*

R17     OMEGA INTO  (2 PIO GAMMA) / (ALL NEUTRALS)
R17           (0.19) OR LESS           KARLSRUHE 69 OSPK                      9/69*

R18     OMEGA INTO  (PIO GAMMA) / (ALL NEUTRALS)
R18           (0.81) OR GREATER        KARLSRUHE 69 OSPK                      9/69*
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

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        P 1        P 2        P 3

 P 1 .874+-.022
 P 2   -.960    .031+-.022
 P 3   -.028      -.252    .094+-.006

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REFERENCES FOR OMEGA


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MAGLIC   61 PRL 7 178          B MAGLIC,ALVAREZ,ROSENFELD,STEVENSON  (LRL)
PEVSNER  61 PRL 7 421          PEVSNER,KRAEMER,NUSSBAUM,RICHARD+  (JHU+NW)
XUONG    61 PRL 7 327          NGUYEN HUU XUONG,GERALD R LYNCH       (LRL)

ALFF     62 PRL 9 325          ALFF,BERLEY,COLLEY,GELFAND + (COLU+RUTGERS)
ARMENTER 62 CERN CONF 90       R ARMENTEROS,R BUDDE +    (CERN+COLL+FRANCE)
BUTTON   62 PR 126 1858        BUTTON,KALBFLEISCH,LYNCH,MAGLIC +     (LRL)
STEVENSO 62 PR 125 687         STEVENSON,ALVAREZ,MAGLIC,ROSENFELD    (LRL)

ALITTI   63 NC 29 515          ALITTI,BATON,BERTHELOT+ (LPCHE+PAR+BARI+BO)
ARMENTER 63 SIENA CONF 1 296   ARMENTEROS,EDWARDS,JACOBSEN+   (CERN+PARIS)
BARMIN   63 SIENA CONF 1 207   BARMIN,DOLGOLENKO,KRESTNIKOV+         (ITEP)
BERTHELO 63 SIENA CONF 2 60    A BERTHELOT                    (CEN-SACLAY)
BUSCHBEC 63 SIENA CONF 1 166   BUSCHBECK,CZAPP+     (VIENNA+CERN+AMSTERDAM)
FICKINGE 63 PRL 10 457         W J FICKINGER,D K ROBINSON,E SALANT   (BNL)
GELFAND  63 PRL 11 436         GELFAND,MILLER,NUSSBAUM,RATAU+ (COLUM+RUTG)
MURRAY   63 PL 7 358           MURRAY,FERROLUZZI,HUWE,SHAFER,SOLMITZ+(LRL)

BARMIN   64 JETP 18 1289       BARMIN,DOLGOLENKO,KRESTNIKOV +        (ITEP)
BEZAGUET 64 PL 12 70           BEZAGUET,NGUYEN KHAC,ROUSSET+ (PAR+BERG+LO)
KRAEMER  64 PR 136 B 496       KRAEMER,MADANSKY,MEER,FIELDS+ (JHU+NW+WOOD)
LUTJENS  64 PRL 12 517         G LUTJENS,J STEINBERGER           (COLUMBIA)
WALKER   64 PL 8 208           WALKER,BOYD,ERWIN,SATTERBLOM +  (WISCONSIN)

BATON    65 NC 35 713          BATON,BERTHELOT,DELER,BENEDETTI+(SAC+BOLOG)
BINNIE   65 PL 18 348          BINNIE,DUANE,JANE,W JONES+ (IC-LOND+MANCHS)
CLARK    65 PR 139 B 1556      CLARK,CHRISTENSON,CRONIN,TURLAY (PRINCETON)
GALTIERI 65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP          (LRL)
MILLER D 65 CU-237(NEVIS 131)  DAVID C MILLER  (THESIS)          (COLUMBIA)
   MILLER 65 INCLUDES DATA OF  GELFAND 63 ABOVE
ZDANIS   65 PRL 14 721         ZDANIS,MADANSKY,KRAEMER,HERTZBACH+(JHU+BNL)

ALFF-STE 66 PR 145 1072        ALFF-STEINBERGER,BERLEY,BRUGGER+ (COL+RUTG)
BAGLIN   66 PL  23  286        +BEZAGUET,DEGRANGE,HAATUFT +     (EP+BERGEN)
DIGIUGNO 66 NC 44A 1272        DI GIUGNO,PERUZZI,TROISE+  (NAPL+FRAS+TRST)
FLATTE   66 PR  145  1050      +HUWE,MURRAY,BUTTON-SHAFER,SOLMITZ+   (LRL)
JAMES    66 PR 142 896         F E JAMES,KRAYBILL         (YALE+BROOKHAVEN)

BALTAY   67 PRL  18  93        +FRANZINI,SEVERIENS,YEH,ZANELLO  (COLUMBIA)
BARASH   67 PR  156  1399      BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)
FELDMAN  67 PR 159 1219        +FRATI,GLEESON,HALPERN,NUSSBAUM+    (PENNA)
HERTZBAC 67 PR 155, 1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
  (SEE ALSO ZDANIS 65)
JACQUET  67 HEIDBG CONF P.364  +NGUYEN-KHAC,BAGLIN,HAATUFT+   (EPP+BERGEN)
  (SEE ALSO BAGLIN 66)
ROOS     67 NP B 2 615         M. ROOS                              (CERN)

ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
BOLLINI  68 NC 56 A 531        +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
BOLLINI1 68 NC 57 A 404        +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)
PISUT    68 NP B 6 325         J.PISUT,M.ROOS                       (CERN)
LEHMANN  68 PRL 20 748         +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

AUGUSTI1 69 PL 28 B 513        +BENAKSAS,BUON,GRACCO,HAISSINSKI,+  (ORSAY)
AUGUSTI2 69 LNC 2 214          +LEFRANCOIS,LEHMANN,MARIN,+         (ORSAY)
BIZZARRI 69  CERN/D.PH. 69-9   +FOSTER,GAVILLET,MONTANET,+     (CERN+CDF)
DANBURG  69  UCRL-19275        JEROME S. DANBURG, THESIS  .          (LRL)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG    (WISC+PRIN+VAND)
FLATTE   69  UCRL 18687        STANLEY M. FLATTE                     (LRL)
GOLDHABE 69 UCRL 19352         +BUTLER,COYNE,HALL,MACNAUGHTON,TRILING(LRL)
KARLSRUH 69  LUND CONFERENCE   KARLSRUHE-CERN GROUP,SEE MAGLIC 69   (RUTG)
MAGLIC   69  LUND CONF.        B.MAGLIC, MESON REVIEW TALK          (RUTG)
MILLER   69 PR 178 2061        R.MILLER,LICHTMAN,WILLMANN         (PURDUE)
STRUGALS 69 PL 29 B 532        +CHUVILO,FENYVES,+          (WARS+JINR+BUDA)
WILSON   69  PRIVATE COMM.     RICHARD WILSON (SEE ALSO PR 178 2095)(HARV)

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η'(958)

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       2   ETA PRIME (958,JPG=0-+)  I=0

           KNOWN ALSO AS XO
           (JP = 2- NOT YET EXCLUDED,)
           (SEE NOTE ON QUANTUM NUMBERS AT END OF ETA
            PRIME LISTINGS)

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           2   ETA PRIME MASS (MEV)

M      85 (957.0)             DAUBER    64 HBC      1.95 K-P
M   K     (958.0)    (1.0)    KALBFLEIS 64 HBC      2.7 K-P               6/66
M   K     KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
M          957.0      3.0     BADIER    65 HBC      3.0 K-P
M       8  960.0      2.0     TRILLING  65 HBC      3.65 PI' P            9/66
M       7  955.0     10.0     COHN      66 DBC      3.3 PI+D              6/66
M          959.0      3.0     LONDON    66 HBC      2.2 K-P               6/66
M          960.0      5.0     MOTT      69 HBC      4.1-5.5 K- P          7/69*
M          957.       1.      RITTENBER 69 HBC      1.7-2.7 K- P          9/69*
M        . . . . . . . . .
M   AVG    957.70     0.81    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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           2   ETA PRIME WIDTH (MEV)

W      85  (4.0)OR LESS       DAUBER    64 HBC      1.95 K-P
W   K      (7.0)OR LESS       KALBFLEIS 64 HBC      2.7 K-P               6/66
W   K     KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
W         (30.0)OR LESS       BADIER    65 HBC      3.0 K-P
W         (15.0)OR LESS       LONDON    66 HBC      2.2 K-P               6/66
W         (10.) OR LESS       RITTENBER 69 HBC      1.7-2.7 K- P          9/69*

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           2   ETA PRIME PARTIAL DECAY MODES

                                                         DECAY MASSES
P1        ETA PRIME INTO  PI+ PI- ETA                    139+ 139+ 548
              P1(N)  ETAS DECAY INTO ALL NEUTRALS
              P1(C)  ETAS DECAY CHARGED
P2        ETA PRIME INTO  PIO PIO ETA                    134+ 134+ 548
              P2(N)  ETAS DECAY INTO ALL NEUTRALS
              P2(C)  ETAS DECAY CHARGED
P3        ETA PRIME INTO  PI+ PI- GAMMA                  139+ 139+   0
              (INCLUDING RHO GAMMA)
P4        ETA PRIME INTO  GAMMA GAMMA                      0+   0
P6        ETA PRIME INTO  RHOO GAMMA                       0+ 765
P10       ETA PRIME INTO  PI+ PI- E+ E-                  139+ 139+  .5+  .5
P11       ETA PRIME INTO  2 PI                           139+ 139
P12       ETA PRIME INTO  3 PI                           139+ 139+ 134
P13       ETA PRIME INTO  4 PI                           139+ 139+ 139+ 139
P14       ETA PRIME INTO  6 PI                           139+ 139+ 139+ 139
P15       ETA PRIME INTO  PIO GAMMA GAMMA                134+   0+   0
P16       ETA PRIME INTO  PIO E+ E-  (VIOLATES C IN      134+  .5+  .5
                              BORN APPROX.)
P17       ETA PRIME INTO  ETA E+ E- (VIOLATES C IN       548+  .5+  .5
                              BORN APPROX.)
P18       ETA PRIME INTO  PIO RHO O (VIOLATES C)         134+ 765
P19       ETA PRIME INTO  PIO OMEGA (VIOLATES C)         134+ 783

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           2   ETA PRIME BRANCHING RATIOS
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Note 1 on η' (958)

In our calculation of the constrained branching fractions of the η' (958) we assume the following decay modes:

(a) $\eta\pi\pi$ (including $\eta\pi^0\pi^0$, 71% of the η' s neutral),

(b) $\rho^0\gamma$,

(c) $\gamma\gamma$.

Note that the γγ value measured by BOLLINI 68 ($5.5^{+3.6}_{-3.0}$%) is slightly different from the result of the overall fit (4.7 ± 2.9%) because of independent measurements of (η' → all neutrals)/(η' → total). In the fit we do not use the constraint.

$$R = \Gamma(\eta' \to \eta\pi^+\pi^-)/\Gamma(\eta' \to \eta\pi^0\pi^0) = 2$$

from I-spin conservation. The result of the fit is in agreement with it, R = 2.0±0.4.

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R1          ETA PRIME INTO (PI+ PI- ETA (NEUTRAL DEC.))/TOTAL
R1   K    68  (0.36)    (0.05)          KALBFLEIS 64 HBC      2.7 K-P       10/66
R1   K        KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
R1       281   0.314     0.026          RITTENBER 69 HBC   1.7-2.7 K-P      9/69*
R1           . . . . . . . .
R1   FIT       0.312     0.017    VALUE FROM CONSTRAINED FIT

R2          ETA PRIME INTO (PI+ PI- NEUTRALS) / TOTAL
R2        33   0.35      0.06           BADIER    65 HBC      3.0 K-P       10/66
R2        39   0.4       0.1            LONDON    66 HBC      2.2 K-P       10/66
R2           . . . . . . . .
R2   AVG       0.363     0.051    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2   FIT       0.375     0.016    VALUE FROM CONSTRAINED FIT
```

Data in parentheses have not been included in our averages.

```
R3          ETA PRIME INTO (PI+ PI- ETA (CHRGD.DECAY))/TOTAL
R3  K   44   (0.12)   (0.02)          KALBFLEIS 64 HBC     2.7 K-P          10/66
R3  K         KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
R3       7    0.07     0.04           BADIER    65 HBC     3.0 K-P          10/66
R3      10    0.1      0.04           LONDON    66 HBC     2.2 K-P          10/66
R3     107    0.123    0.014          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*
R3          . . . . . . . . . .
R3  AVG       0.116    0.013    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT       0.1242   0.0067    VALUE FROM CONSTRAINED FIT

R4          ETA PRIME INTO (PI+ PI- NEUTRALS (EXCLUDING
R4          PI+ PI- ETA (NEUTR.DEC.))) / TOTAL
R4  K   10   (0.05)   (0.04)          KALBFLEIS 64 HBC     2.7 K-P          10/66
R4  K         KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
R4      42    0.045    0.029          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*
R4          . . . . . . . . . .
R4  FIT       0.063    0.012     VALUE FROM CONSTRAINED FIT

R5          ETA PRIME INTO (NEUTRALS) / TOTAL
R5  K   54   (0.25)   (0.05)          KALBFLEIS 64 HBC     2.7 K-P          10/66
R5  K         KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
R5      16    0.24     0.17           BADIER    65 HBC     3.0 K-P          10/66
R5      32    0.3      0.1            LONDON    66 HBC     2.2 K-P          10/66
R5     123    0.189    0.026          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*
R5          . . . . . . . . . .
R5  AVG       0.197    0.027    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R5  FIT       0.205    0.021     VALUE FROM CONSTRAINED FIT

R6          ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/TOTAL
R6  K   42   (0.22)   (0.04)          KALBFLEIS 64 HBC     2.7 K-P          10/66
R6  K         KALBFLEISCH 64 SUPERSEDED BY RITTENBERG 69
R6  B   35   (0.34)   (0.09)          BADIER    65 HBC     3.0 K-P          10/66
R6  B       CONTROVERSIAL BACKGROUND SUBTRACTION
R6      20    0.2      0.1            LONDON    66 HBC     2.2 K-P          10/66
R6     298    0.329    0.033          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*
R6          . . . . . . . . . .
R6  AVG       0.316    0.038    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
R6  FIT       0.296    0.026     VALUE FROM CONSTRAINED FIT

R7          ETA PRIME INTO (PI+ PI- GAMMA (INCLUDING RHO GAMMA))/(PI PI ETA)
R7            0.25     0.14           DAUBER    64 HBC     1.95 K-P         10/66
R7          . . . . . . . . . .
R7  FIT       0.451    0.060     VALUE FROM CONSTRAINED FIT

R8          ETA PRIME INTO (PI0 E+ E-)/TOTAL
R8           (0.013) OR LESS          RITTENBER 65 HBC            2.7 K-P   10/66

R9          ETA PRIME INTO (ETA E+ E-)/TOTAL
R9           (0.011) OR LESS          RITTENBER 65 HBC            2.7 K-P   10/66

R10         ETA PRIME INTO (PI0 RHO0)/TOTAL
R10          (0.04)  OR LESS          RITTENBER 65 HBC            2.7 K-P   10/66

R11         ETA PRIME INTO (PI0 OMEGA) /TOTAL
R11          (0.08)  OR LESS          RITTENBER 65 HBC            2.7 K-P   10/66

R12         ETA PRIME INTO (PI+ PI- E+ E-)/TOTAL
R12          (0.006) OR LESS          RITTENBER 65 HBC            2.7 K-P   10/66

R13         ETA PRIME INTO (2 PI)/TOTAL
R13          (0.07)  OR LESS  COMP.BY LONDON    66 HBC                      10/66

R14         ETA PRIME INTO (3 PI)/TOTAL
R14          (0.07)  OR LESS  COMP.BY LONDON    66 HBC                      10/66

R15         ETA PRIME INTO (4 PI)/TOTAL
R15          (0.01)  OR LESS  COMP.BY LONDON    66 HBC                      10/66

R16         ETA PRIME INTO (6 PI)/TOTAL
R16          (0.01)  OR LESS  COMP.BY LONDON    66 HBC                      10/66

R18         ETA PRIME INTO (RHO0 GAMMA)/(PI PI ETA)
R18           0.31     0.15           DAVIS     68 HBC     5.5 K- P          9/68
R18         . . . . . . . . . .
R18 FIT       0.451    0.060     VALUE FROM CONSTRAINED FIT

R19         ETA PRIME INTO (2 GAMMA)/TOTAL
R19      5    0.055    0.036     0.030 BOLLINI  68 CNTR    1.9 PI- P         9/68
R19         . . . . . . . . . .
R19 FIT       0.047    0.031     VALUE FROM CONSTRAINED FIT .

R20         ETA PRIME INTO (PI+PI-)/TOTAL
R20          (0.02)  OR LESS          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*

R21         ETA PRIME INTO (PI+PI-PI0)/TOTAL
R21          (0.05)  OR LESS          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*

R22         ETA PRIME INTO (PI+PI+PI-PI-)/TOTAL
R22          (0.01)  OR LESS          RITTENBER 69 HBC.    1.7-2.7 K-P       9/69*

R23         ETA PRIME INTO (PI+PI+PI-PI-PI0)/TOTAL
R23          (0.01)  OR LESS          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*

R24         ETA PRIME INTO (PI+PI+PI-PI- NEUTRALS)/TOTAL
R24          (0.01)  OR LESS          RITTENBER 69 HBC     1.7-2.7 K-P       9/69*
```

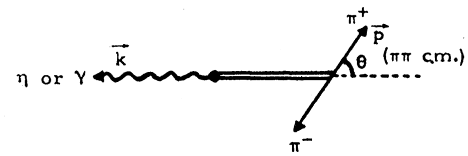
Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4
P 1	.436+-.023			
P 2	-.455	.221+-.043		
P 3	-.386	-.342	.296+-.026	
P 4	.154	-.786	-.004	.047+-.029

UNCERTAINTY IN THE J^P ASSIGNMENT OF $\eta'(958)$

For the dominant (66%)$\pi\pi\eta$ decay mode of the η' , since the Dalitz plot population is rather flat (DAUBER 64, LONDON 66, RITTENBERG 69, DUFEY 69), and in particular does not vanish at the edges of the plot, the J^P= Normal series may be ruled out.



By the notation of the sketch, any Normal matrix element would have a factor $\sin\theta$ and would thus go to zero at the edge of the Dalitz plot [C. Zemach, Phys. Rev. 133, B1201 (1964)].

This leaves the Abnormal series 0^-, 1^+, 2^-, $\cdots$. In the discussion below, the confidence levels are values from RITTENBERG 69, based on fits of 278 $\pi^+\pi^-\eta_{neut}$ decays (see ~ 100 more in the compilation by LONDON 66):

$J^P = 0^-$: The simplest matrix element M is constant; confidence level = 7% .

1^+: $\underline{M} = \underline{k}$. This simply does not fit (confidence level < 10^{-10}). Of course a strong $\pi\pi$ final-state interaction could help, but it seems unlikely that it could make the fit acceptable.

2^-: $\underline{M} = a\underline{kk} + b\underline{pp}$, where a and b are arbitrary. Here, according to London et al. , $|\underline{M}|^2$ gives a good fit to the data with $b \approx 3a$. According to Rittenberg, it gives a confidence level of 0.6% , also with $b \approx 3a$.

A recent spark chamber experiment at CERN (DUFEY 69), based on the Dalitz plot distribution of about 300 $\pi^+\pi^-\eta_{neut}$ decays, leads to the following similar conclusions:

$J^P = 0^-$: This fits well (if one allows the matrix element to vary linearly with the η kinetic energy).

1^+: Excluded (unless one assumes very drastic form factors).

2^-: Cannot be excluded. The simplest matrix element (see above) gives a poor fit (3% , with $|b/a| \approx 4$), but it can easily be improved with a slightly more complicated matrix element.

Hence, to rule out $J^P = 2^-$, one turns to the 30% mode $\eta' \to \pi^+\pi^-\gamma$, and the usual J^P assignment is based heavily on this Dalitz plot. The plot by Rittenberg, with 132 events, shows that the decay is mainly $\rho^0\gamma$, and the θ distribution shows a strong preference for equatorial decays:

$J^P = 0^-$: Fits well. The only matrix element is magnetic dipole, M_1. $|M_1|^2$ predicts $d\sigma/d\omega \propto \sin^2\theta$, and the confidence level is 47%.

1^+: Does not fit (confidence level = 0.002%). The matrix element yields a $1 + \cos^2\theta$ distribution.

2^-: Fits well. Again the simplest transition is M_1, and this time the predicted distribution is $6 + \sin^2\theta$, with a confidence level of 11%.

We should warn that the $\pi\pi\gamma$ decay has a very high Q value ($0 < k < 460$ MeV), with the average value of k about 200 MeV. Hence we must not be too quick to consider only the smallest powers of $k/M_{\eta'}$ in matrix elements. Specifically this warning means the following. We in this note have considered only the lowest possible multipole transition. Thus the 11% confidence level quoted above for the 2^- hypothesis was based on an M_1 matrix element. But of course E_2 is also possible, and has an independent coupling that could be large. It can interfere with M_1 to give almost any distribution. Rittenberg finds a confidence level of 46% for $J^P = 2^-$ when a variable amount of E_2 is included in the matrix element. The 1^+ fit can also be improved by adding higher-order matrix elements. So the $\pi\pi\gamma$ mode is likely to be somewhat unreliable. We want to thank V. I. Ogievetsky and W. Tybor for pointing this out to us. (See Zaslavsky, Ogievetsky, and Tybor, JINR Preprint E2-4061, Dubna, 1968).

So all available Dalitz plot data for both modes seem to permit $J^P = 2^-$. London et al. have a qualitative remark that the 2^- hypothesis is inconsistent with their observed ~3:1 ratio of $\pi\pi\eta:\pi\pi\gamma$, and Rittenberg finds no correlations between the decay plane of the η' and the production coordinate system, but neither of these observations, although adding weight against 2^-, rules it out.

Finally, we note that, since a J = 1 particle cannot decay into $\gamma\gamma$, an observation of a $\gamma\gamma$ decay excludes $J^P = 1^+$. BOLLINI 68 observed five events of this kind over a background of only about one event. The probability that this is due to a statistical fluctuation of the background is less than 1%; hence at the same level of confidence, $J^P = 1^+$ can be excluded.

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REFERENCES FOR ETA PRIME

DAUBER	64 PRL 13 449	DAUBER,SLATER,SMITH,STORK,TICHO	(UCLA)JP
ALSO	64 DUBNA CONF 1 418	DAUBER,SLATER,L T SMITH,STORK,TICHO	(UCLA)
KALBFLEI	64 PRL 13 349	G.R.KALBFLEISCH,O.DAHL,A.RITTENBERG	(LRL)JP
BADIER	65 PL 17 337	BADIER,DEMOULIN,BARLOUTAUD +	(PAR+SAC+ZEEMA)
KIENZLE	65 PL 19 438	KIENZLE,MAGLIC,LEVRAT,LEFEBVRES +	(CERN)
RITTENBE	65 PRL 15 556	RITTENBERG,KALBFLEISCH	(LRL+BNL)
TRILLING	65 PL 19 427	+BROWN,GOLDHABERS,KADYK,SCANIO	(LRL)
COHN	66 PL 21 347	COHN,MCCULLOCH,BUGG,CONDO	(ORNL+TENN+UNCAR)
LONDON	66 PR 143 1034	LONDON,RAU,SAMIOS,GOLDBERG +	(BNL+SYRACUSE)IJP
BOLLINI	68 NC 58 A 289	+BUHLER,DALPIAZ,MASSAM+	(CERN+BGNA+STRB)
DAVIS	68 PL 27 B 532	+AMMAR,MOTT,DAGAN,DERRICK,FIELDS	(NWES+ANL)
MOTT	69 PR 177 1966	+AMMAR,DAVIS,KROPAC,SLATE,DAGAN+	(NWES+ANL)
RITTENBE	69 UCRL-18863	ALAN RITTENBERG (THESIS)	(LRL)I=0

QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN THE DATA CARDS

MARTIN	66 PL 22,352	MARTIN,CRITTENDEN,SCHROEDER	(INDIANA U)I
BARBARO-	68 PRL 20 349	BARBARO-GALTIERI,MATISON,RITTENBERG+	(LRL)I=0
BARLOUTA	68 PL 26 B 674	BARLOUTAUD+	(SACLAY+AMSTD+BOLOG+WEIZM+E.P.)I=0
DUFEY	69 PL 29 B 605	+GOBBI,POUCHON,CNOPS,+	(ETHZ+CERN+SACL) IJP

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δ(962) 36 DELTA MESON (962,JPG=) I = 1,2

Note on δ(962)

The $\delta^-(962)$ was originally seen with the CERN MMS, KIENZLE 65. Other missing-mass spectrometers (OOSTENS 66, BANNER-1 67, BANNER-2 67) have added nothing conclusive to this evidence.

A claim in the 2π system (ALLEN 66) has been contradicted (JACOBS 66, WEST 66, CLEAR 67, ROOS 67), and claims in the 3π system (ALLISON 67, JUHALA 68) likewise (SAMIOS 68, KRUSE 69). For discussion, see SAMIOS 68 and MAGLIĆ 69.

The only support comes from BARNES 69, who see a peak in the $\eta\pi$ system, and who claim that it cannot be explained by the kinematic effect discussed below under 2a.

The following references have possible relevance to the existence of the δ(962):

Data in parentheses have not been included in our averages.

1) The $\pi_N(1016)$ may be interpreted as a virtual bound state in the $K\bar{K}$ channel. It would then correspond to a narrow resonance at about $975 \pm ^{15}_{10}$ MeV (ASTIER 67) in open channels, e.g., $\eta\pi$ or 5π.

2) Further $\eta\pi$ enhancements have been reported at masses in the 960-980 MeV region. As evidences for a resonance they are however not yet convincing, because there are kinematic effects that can produce $\eta\pi$ peaks in that mass region:

a) In the reactions $K^-n \to \Lambda\pi^-$(MM) and $K^-p \to \Lambda\pi^+\pi^-$(MM) (studied by AMMAR 68, CRENNELL 69, MILLER 69) with selection of the missing mass (MM) in the $\eta(549)$ region, a spurious $\delta(962)$ peak can arise from contamination with $\Lambda\rho^-\pi^0$ final states. This has been pointed out by CRENNELL 69.

b) In final states containing many pions [e.g., $2\pi^+2\pi^-\pi^0$, $(3\pi)^{\pm}\pi^0$], and with the ω copiously produced, the constraint of at least one η combination in the $\pi^{\pm}\pi^+\pi^-\pi^0$ mass "fakes" a bump in the mass region around 960 MeV, due to reflections from the ω. This remark may apply to the observations of DEFOIX 68, CAMPBELL 69, and OTWINOWSKI 69. .

If we accept $\delta \to \pi\eta$ by strong decay, then $I^G = 1^-$; nonobservation of 3π decay can be explained by choosing $J^P = 0^+$, or simply by saying that 3π background is too large to permit detection. These quantum numbers $1^-(0^+)$ are then the same as those most likely for $\pi_N(1016)$, which could be just the $\bar{K}K$ decay mode of $\delta(962)$.

An unattractive alternative is to believe that δ is really very narrow, and guess that its $\pi\eta$ decay is G-violating electromagnetic. (It is not clear whether there would be competition from $\pi\pi\eta$ decay, which is strong but has much smaller phase space.) However, in this electromagnetic (em) case, one would also expect slightly faster decay into $\pi\pi$, and we are not sure whether this mode should have been detected. To see why we expect $\pi\pi$ decay, note that these em decays into $\pi^-\pi^0$ or $\pi^-\eta$ involve emission and reabsorption of a photon, with rates proportional to e^4 (also $\pi\pi$ has slightly larger phase space than $\pi\eta$). Neutral em decays (as in the familiar $\eta^0 \to 3\pi$) have selection rules either

$$\Delta G = \text{Yes}, \quad \Delta|I| = 1,$$

or

$$\Delta G = \text{No}, \quad \Delta|I| = 2,$$

but charged decays ($\delta^- \to \pi^-\pi^0$ or $\pi^-\eta$) have no such rules (except $\Delta|I| \leq 2$).

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                   36  DELTA (962) MASS (MEV)

M     262  962.0      5.0              KIENZLE   65 MMS   -  3-5 PI- P        9/66
M   B      NOTE THAT BANNER 1 AT 1.8 PI-P DOES NOT SEE IT.
M   O      (966.0)    (8.0)            OOSTENS   66 MMS  +  3.8 PP TO D + MM  9/66
M   O      FOR A CONTRADICTORY RESULT SEE BANNER2 67        3.8 PP TO D + MM 11/67
M   A      (980.)     (10.)            AMMAR     68 HBC  +-  5.5 K- P,ETA PI  9/68
M   A      MASS+WIDTH OF THIS PEAK MAKE IDENTIFICATION WITH DELTA DUBIOUS.    9/68
M          (975.0)                     DEFOIX    68 HBC  +-  1.2 PB P,ETA PI  3/69*
M           970.0     15.0             BARNES    69 HBC   -  4-5 K-P,PI-ETA   9/69*
M          (980.0)   (10.0)            MILLER    69 HBC   -  4.5 K-N,ETA PI   7/69*
M   D   22 (948.0)    (6.0)            OTWINCWSK 69 HBC  +- 8 PI+P,P DO PI   11/69*
M   D      MASS+WIDTH OF THIS PEAK MAKE IDENTIFICATION WITH DELTA DUBIOUS.   11/69*
M   D      OTWINOWSKI SEES CHAIN DO(1329)--DELTA(948)PI--ETA PI+ PI-         11/69*
M          . . . . . . . . .
M   AVG     962.8      4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                   36  DELTA (962) WIDTH (MEV)

W     262   (5.0)   OR LESS            KIENZLE   65 MMS   -. 3-5 PI- P        9/66
W   A      (80.)     (30.)             AMMAR     68 HBC  +-  5.5 K- P,ETA PI  9/68
W          (25.0)                      DEFOIX    68 HBC  +-  1.2 PB P,ETA PI  3/69*
W          (50.0)   OR LESS            BARNES    69 HBC   -  4-5 K-P,PI-ETA   9/69*
W          (60.0)    (30.0)            MILLER    69 HBC   -  4.5 K-N,ETA PI   7/69*

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                   36  DELTA MESON PARTIAL DECAY MODES

P2         DELTA MESON INTO 3 PI                           134+ 134+ 134
P3         DELTA MESON INTO 4 PI                           134+ 134+ 134+ 134
P5         DELTA MESON INTO ETA PI                         548+ 134

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                   36  DELTA MESON BRANCHING RATIOS

R1         CHARGED DELTA INTO (1 CHARGED) / (3 OR MORE CHARGED)
R1            1.3        0.9       0.7   KIENZLE   65 MMS   -  3-5 PI- P      9/66

R2         DELTA MESON INTO ETA PI
R2         SEEN                          BARNES    69 HBC   -  4-5 K-P,PI-ETA  9/69*

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                   36  SIGMA(MICROB.) FOR PI- P -- P X-

CS         15 +- 5 BRANCH.RATIO ABOVE.KIENZLE    65  MMS  -   3-5 PI-          7/67
CS     KIENZLE 15. REVISED  TO A FEW...FOCACCI   66  MMS  -   3-5 PI-          7/67
CS         17 OR LESS (2 PRONGS)        JACOBS   66  HBC      3.2  PI-         7/67
CS           (3.0)OR LESS /(GEV/C)**2 BANNER 1   67 MMS   -   1.8 PI-P,  P+MM  9/67
CS         3.3 +- 1.7 PI- PI+ PI- ETA CHUNG      68  HBC                       5/68
CS         .2 OR LESS PI- PI+ PI- MM  CHUNG      68  HBC    3.2-4.2 PI-        5/68
CS         1.5OR LESS PI- PI+ PI- PIO CHUNG      68  HBC       3.2 PI-         5/68

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                         REFERENCES ON DELTA(962)

TURKOT    63 SIENNA CONF 1 661 +COLLINS,FUJII,KEMP+         (BNL+PITTSBURGH)
KIENZLE   65 PL  19  438       + MAGLIC,LEVRAT,LEFEBVRES +            (CERN)
ALLEN D   66 PL 22  543        +GP FISHER,G GODDEN,L MARSHALL,SEARS (COLO)G=+
FOCACCI   66 PRL  17  890      + KIENZLE,LEVRAT,MAGLIC,MARTIN         (CERN)
JACOBS    66 UCRL 16877-THESIS  +O.DAHL, J. KIRZ, D.H.MILLER           (LRL)
OOSTENS   66 PL  22  708       +CHAVANON,CROZON,TOCQUEVILLE    (SACLAY,CF)I=1
WEST      66 PR 149 1089       WEST,BOYD,ERWIN,WALKER            (WISCONSIN)

ALLISON   67 PL 25B 619        +CRUZ+    (OXF+MUN+BIRM+RUTH+GLASG+LON(IC))
ASTIER    67 PL  25 B  294     +MONTANET,BAUBILLIER,DUBOC+  (CDF+CERN+IOR)
BANNER 1  67 PL  25 B  300     +FAYOUX,HAMEL,ZSEMBERY,CHEZE+ (SACLAY+CAEN)
BANNER 2  67 PL 25 B 569       +CHEZE,HAMEL,MAREL,TEIGER,CROZON+(CDF+SACL)
CLEAR     67 NC 49A 399        +JOHNSTON+PILCHER+COOPER+(TORONTO+ANL+WISC)
ROOS      67 NP B 2  615       M. ROOS                                (CERN)

AMMAR     68 PRL 21 1832       +DAVIS,KROPAC,MOTT,SLATE,WERNER+ (NWES+ANL)
CHUNG S   68 PR 165 1491        +O.DAHL, J. KIRZ, D.H.MILLER           (LRL)
DEFOIX    68 PL 28 B 353       +RIVET,SIAUD,CONFORTO,SHIVELY(CDF+IPE+CERN)
GALTIERI  68 PRL 20 349        BARBARO-GALTIERI,MATISON,RITTENBERG+  (LRL)
JUHALA    68 PL 27 B 257       +LEACOCK,RHODE,KOPELMAN,LIBBY+  (ICWA+COLO)
SABRE CO  68 PL 26 B 674       BARLOUTAUD+       (SACL+AMST+BGNA+REHO+EPOL)
SAMIOS    68 PHILA. CONF.P.121 N.SAMIOS                                (BNL)

BARNES    69 PRL 23 610        +CHUNG,EISNER,BASSANO,GOLDBERG+   (BNL+SYR)
CAMPBELL  69 PRL 22 1204       J.H.CAMPBELL,LICHTMAN,LOEFFLER,+   (PURDUE)
CRENNELL  69 PRL 22 1398       +KARSHON,KWAN WU LAI,+             (BNL+NYU)
KRUSE     69 PR 177 1951       KRUSE,LOOS,GOLDWASSER            (ILLINOIS)
MAGLIC    69  LUND CONF.       B.MAGLIC                             (RUTG)
MILLER    69 PL 29 B  255      D.H.MILLER,S.L.KRAMER,D.D.CARMONY,+(PURDUE)
NELLEN    69  PRIVATE COMM.    B.NELLEN                        (BONN+CERN)
OTWINOWS  69 PL 29 B 529       S.OTWINOWSKI                         (WARSAW)

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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

H(990)

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35  H (990, JPG=A -)  I=0

IT IS SHOWN BY BARBARO-GALTIERI 68 THAT THE PRE-1968
H ENHANCEMENT IS COMPATIBLE WITH BEING ENTIRELY DUE
TO MISIDENTIFIED  RHOO-GAMMA DECAYS OF ETA PRIME(958).
HOWEVER, GOLDHABER 69 REPORT A NEW (PI+PI-PIO)
ENHANCEMENT AT ABOUT THE SAME MASS, M=1000 MEV,
SEEN UNDER CONDITIONS DIFFERENT FROM THOSE OF THE
EARLIER OBSERVATIONS.  OMITTED FROM TABLE.
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                  35  H  MASS  (MEV)

M        50  975.0     15.0          BARTSCH   64 HBC      4.0 PI+ P      8/66
M        30 (975.0)   APPROX         GOLDHABER 65 HBC      3.65 PI+P      9/66
M        30  998.      10.           BENSON    66 DBC      3.65 PI+D      9/66
M           (980.)    APPROX.        COHN      67 DBC      3.3 PI+ D      1/67
M            . . . . . . . . .
M   AVG      990.9     10.6    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
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                  35  H  WIDTH  (MEV)

W        90 (120.0)                  BARTSCH   64 HBC      4.0 PI+ P      8/66
W        30   45.0     30.0          BENSON    66 DBC      3.65 PI+ D    10/66
W            (60.)    OR LESS        COHN      67 DBC      3.3 PI+ D      1/67
------ --------- --------- --------- --------- --------- --------- --------

                . 35  H  PARTIAL DECAY MODES

                                                         DECAY MASSES
P1          H INTO 3 PI                                  139+ 139+ 134
P2          H INTO RHO PI                                765+ 139
------ --------- --------- --------- --------- --------- --------- --------

                  H MESCN CROSS SECTION (MICROBARNS)

CS           75.0      15.0          BENSON    66 DBC  3.65 PI+D TO HPP   9/66
CS          (50.)                    COHN      67 DBC    3.3 PI+D TO HPP  1/67
****** ********* ********* ********* ********* ********* ********* ********
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REFERENCES ON H MESON


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BARTSCH  64 PL  11  167       AACHEN-ZEUTHEN-BIRM-BONN-HAMB-MUNCHEN COLL
GOLDHABE 65 CORAL CABLES P 76 G. GOLDHABER                         (LRL)
BENSON   66 PRL 17 1234       +MARQUIT,ROE,SINCLAIR,VANDER VELDE  (MICH.)IJP
    BENSON 66 ANALYSIS FAVORS JP=1+
COHN     67 NP B1 57          +MC CULLOCH,BUGG,CONDO   (OAK R.+UNIV.TENN)
ROSENFEL 67 RMP 39 1,APPENDIX  ROSENFELD,BARBARO-GALTIERI+(LRL+CERN+YALE)
ARMENISE 68 PL 26B 336        +GHIDINI,FORINO+ (BARI+BOLOGN+FIRENZ+ORSAY)
BARBARO- 68 PHILAD.CONF.P.137 A.BARBARO-GALTIERI,P.SODING            (LRL)
FUNG     68 PRL 21  47        +JACKSON+PU+BROWN+GIDAL    (U.C.RIVERS+LRL)
GOLDHABE 69  LUND CONF.       GERSON GOLDHABER                       (LRL)
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$\pi_N(1016) \to K\bar{K}$

```
16 PI(1016,JPG=0+-) I=1

STILL NOT DECIDED WHETHER (K KBAR) RESONANCE, VIRTUAL
BOUND STATE OR ANTIBOUND STATE. MAY BE RELATED
TO THE DELTA (962)
------ --------- --------- --------- --------- --------- --------- --------

                  16 PI(1016) MASS  (MEV)

M       143(1003.3)     7.0+SYSTEMATIC RCSENFELD 65 RVUE +-                     8/66
M          SCAT. LENGTH 2 TO 6 FERMIS.BALTAY    66 HBC       3.7 PBAR P         8/66
M   A   100(1016.)     (10.)           ASTIER    67 HBC  +-  0 PBAR P           7/67
M   A    SCATT.LENGTH ALSO FITS, SEE BELOW
M        SCATT.LENGTH +2.5 +-1. FERMI  ASTIER    67 HBC  +-  0-1.2 PBAR P       7/67
M        OR CMPLX, RE PART=-2.3 F      ......    .. ...  ..  ..... .... .       7/67
M                 IM PART=.5F OR LESS  ......    .. ...  ..  ..... .... .       7/67
------ --------- --------- --------- --------- --------- --------- --------

                  16 PI(1016) WIDTH (MEV)

W       143  (57.0)    13.0+SYSTEMATIC ROSENFELD 65 RVUE +-                     8/66
W   A   100  (25.) APPROX.             ASTIER    67 HBC  +- SEE NOTE A ABOVE    9/67
------ --------- --------- --------- --------- --------- --------- --------

                  16 PI(1016) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1         PI(1016) INTO K KBAR                          493+ 497
P2         PI(1016) INTO ETA PI                          548+ 139
------ --------- --------- --------- --------- --------- --------- --------

                  16 PI(1016) BRANCHING RATIOS

R1         PI(1016) INTO (ETA PI) / (K KBAR)
R1          (5.0)  OR LESS             ASTIER    67 HBC        0. PBAR P         9/67
****** ********* ********* ********* ********* ********* ********* ********
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REFERENCES FOR PI(1016)


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ARMENTER 65 PL 17 344         ARMENTEROS,EDWARDS,JACOBSEN +  (CEPN+PARIS)
BARASH   65 PR  139 B  1659   +FRANZINI,KIRSCH,MILLER,STEINBERGER+(COLUM)
ROSENFEL 65 OXFORD CONF 58    A H ROSENFELD                   (LRL--RVUE)
BALTAY   66 PR  142 B  932    +LACH,SANDWEISS,TAFT,YEH,STONEHILL+  (YALE)
ASTIER   67 PL  25 B  294     +MONTANET,BAUBILLIER,DUBOC+  (CDF+CERN+IDR)
  ASTIER 67 INCLUDES DATA OF BARLOW 67,CONFORTO 67,ARMENTEROS 65.   /
BAILLON  67 NC 50A 393        +EDWARDS+D.ANDLAU+ASTIER+     (CERN+CDF +IR)
BARLOW   67 NC  50 A  701     +MONTANET,D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
CONFORTO 67 NP B3 469         CONFORTO,MARECHAL,MONTANET+(CERN+PARIS+LIV)
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φ(1019)

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4  PHI (1019,JPG=1-- ) I=0
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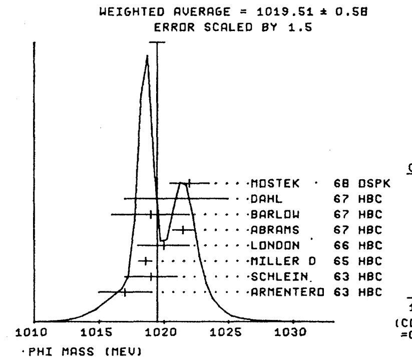
                  4  PHI  MASS (MEV)

M          1017.0     2.0          ARMENTERO 63 HBC      0.0 PBAR P
M          1019.0     2.0          SCHLEIN   63 HBC    2.0 K- P
M          1018.6     0.5          MILLER D  65 HBC      0.0 PBAR P      8/66
M          1020.0     2.0          LONDON    66 HBC      2.2 K-P         6/66
M          1021.5     0.8          ABRAMS    67 HBC    4.2 K- P         11/67
M          1019.      3.           BARLOW    67 HBC      1.2 PBAR P     11/66
M          1021.0     4.0          DAHL      67 HBC      1-4 PI- P       9/66
M      165 1022.      1.5          MOSTEK    68 OSPK   1.8 GAMMA + C     6/68
M        . . . . . . . . .
M   AVG    1019.51    0.58    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
                              (SEE IDEOGRAM BELOW )
```

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                  4  PHI  WIDTH (MEV)

W            3.4      1.7          ARMENTERO 63 HBC      0.0 PBAR P
W       34  (5.0) OR LESS          SCHLEIN   63 HBC      2.0 K-P
W            3.5      1.0          MILLER D  65 HBC      0.0 PBAR P      8/66
W            6.0      4.0          LONDON    66 HBC      2.2 K-P         6/66
W            1.8      3.0    1.5   ABRAMS    67 HBC    4.2 K- P         11/67
W          (10.)  OR LESS          BARLOW    67 HBC      1.2 PBAR P     11/66
W      165  (4.5)    (3.0)  (2.0)  MOSTEK    68 OSPK   1.8 GAMMA + C     6/68
W            4.2      0.9          AUGUSTIN  69 OSPK   E+ E- CCLL.BEAMS 10/68
W            4.1      0.5          SIDOROV   69 OSPK   E+ E- COLL.BEAMS  9/69*
W        . . . . . . . . .
W   AVG      3.95     0.38    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
------ --------- --------- --------- --------- --------- --------- --------

                  4  PHI PARTIAL DECAY MODES

                                                         DECAY MASSES
P1      PHI INTO K+ K-                                   493+ 493
P2      PHI INTO K01 K02                                 497+ 497
P3      PHI INTO PI+ PI- PIO (INCLUDING RHO PI)          139+ 139+ 134
P4      PHI INTO PI+ PI- (VIOLATES G)                    139+ 139
P5      PHI INTO E+  E-                                   .5+  .5
P6      PHI INTO MU+ MU-                                 105+ 105
P7      PHI INTO PIO GAMMA                               134+   0
P8      PHI INTO ETA GAMMA                               548+   0
P9      PHI INTO PI+PI-GAMMA                             139+ 139+   0
P10     PHI INTO OMEGA GAMMA (VIOLATES C)                783+   0
P11     PHI INTO ETA PIO (VIOLATES C)                    548+ 134
P12     PHI INTO RHO GAMMA (VIOLATES C)                  765+   0
------ --------- --------- --------- --------- --------- --------- --------

                  4  PHI  BRANCHING RATIOS

R1        PHI INTO (K+ K-)/TOTAL
R1  B  27  (0.26)   (0.06)         BADIER    65 HBC   (SEE NOTE B BELOW) 10/66
R1    252   0.48     0.04          LINDSEY   66 HBC       2.7 K-P        10/66
R1        . . . . . . . . .
R1  FIT     0.455    0.033    VALUE FROM CONSTRAINED FIT

R2        PHI INTO (K1 K2)/TOTAL
R2  B  25  (0.23)   (0.06)         BADIER    65 HBC   (SEE NOTE B BELOW) 10/66
R2    167   0.40     0.04          LINDSEY   66 HBC       2.7 K-P        10/66
R2        . . . . . . . . .
R2  FIT     0.364    0.034    VALUE FROM CONSTRAINED FIT

R3        PHI INTO (PI+ PI- PIO (INCL.RHO PI))/TOTAL
R3  B  57  (0.51)   (0.09)         BADIER    65 HBC       3.0 K-P        10/66
R3  B     CONTROVERSIAL BACKGROUND SUBTRACTION
R3     30   0.12     0.08          LINDSEY   66 HBC       2.7 K-P        10/66
R3        . . . . . . . . .
R3  FIT     0.181    0.042    VALUE FROM CONSTRAINED FIT

R5        PHI INTO (K1 K2)/(K KBAR)
R5     10   0.40     0.10          SCHLEIN   63 HBC       2.0 K-P        10/66
R5     52   0.48     0.07          BADIER    65 HBC       3.0 K-P        11/67
R5          0.44     0.07          LONDON    66 HBC       2.2 K-P        10/66
R5        . . . . . . . . .
R5  AVG     0.448    0.044    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  FIT     0.444    0.032    VALUE FROM CONSTRAINED FIT

R6        PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(K KBAR)
R6          0.30     0.15          LONDON    66 HBC       2.2 K-P        10/66
R6        . . . . . . . . .
R6  FIT     0.221    0.063    VALUE FROM CONSTRAINED FIT
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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R7          PHI INTO (PI+ PI- PIO (INCL.RHO PI))/(K1 K2)
R7            (0.3)   OR LESS          BERLEY    65 HBC      2.9 PI+P          10/66
R7             0.667    0.157          AUGUSTIN  69 OSPK   E+ E- COLL.BEAMS   4/69*
R7          . . . . . . . . . .
R7  FIT        0.50     0.15     VALUE FROM CONSTRAINED FIT

R8          PHI INTO (PI+ PI-)/(K KBAR)
R8            (0.2)   OR LESS          LONDON    66 HBC      2.2 K-P           10/66

R9          PHI INTO (E+ E-)/(K+ K-)   (UNITS 10**-4)
R9      40    6.1       1.7            BECKER    68 CNTR         GAMMA C        9/68

R10         PHI INTO (MU+ MU-)/TOTAL (UNITS 10**-4)
R10          (53.)   OR LESS           GALTIERI  65 HBC    2.7 K- P           10/66
R10           (7.4)  OR LESS           CHASE     67 CNTR     PHOTOPROD.        6/68
R10            3.5      3.5      1.8   WEHMANN   68 OSPK   12 K- C             6/68

R11         PHI INTO (ETA GAMMA)/TOTAL
R11           (0.2)   OR LESS          BADIER    65 HBC      3.0 K-P           10/66
R11           (0.08)  OR LESS          LINDSEY   66 HBC      2.7 K-P           10/66

R12         PHI INTO (PI+ PI- GAMMA)/(K KBAR)
R12           (0.05)  OR LESS          LINDSEY   65 HBC      2.7 K-P           10/66

R13         PHI INTO (ETA NEUTRALS)/(K KBAR)
R13           (0.15)  OR LESS          LINDSEY   66 HBC      2.7 K-P           10/66

R14         PHI INTO (OMEGA GAMMA) / TOTAL
R14           (0.05)  OR LESS          LINDSEY   66 HBC      2.7 K-P           10/66

R15         PHI INTO (RHO GAMMA) / TOTAL
R15           (0.02)  OR LESS          LINDSEY   66 HBC      2.7 K-P           10/66

R16         PHI INTO (E+ E-)/TOTAL     (UNITS 10**-4)
R16 A    5   (6.6)     (4.4)    (2.8)  ASTVACATU 68 OSPK    4 PI- P            6/68
R16 A    ERROR OF ASTVACATUROV 68 DOES NOT INCLUDE SIGMA(PHI) UNCERTAINTY.     6/68
R16     27    7.2       3.9            BINNIE    68 OSPK   1.6 PI- P           6/68
R16      9    6.1       2.6            BOLLINI   68 CNTR   1.9 PI- P           9/68
R16           3.96      0.62           AUGUSTIN  69 OSPK   E+ E- COLL.BEAMS   4/69*
R16           3.4       0.4            SIDOROV   69 OSPK   E+ E- COLL.BEAMS   9/69*
R16         . . . . . . . . . .
R16 AVG       3.63      0.33    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R17         PHI INTO (PIO GAMMA)/(TOTAL)
R17           (.0035)OR LESS           BEMPORAD  69 CNTR    5.5 GAMMA N        7/69*
R17           (0.01) OR LESS           SIDOROV   69 OSPK   E+ E- COLL.BEAMS   9/69*

R18         PHI INTO (PI+ PI-)/(TOTAL)
R18 L         (0.05) OR LESS           LINDSEY2  65 HBC    1.7-2.7 K-P        11/69*
    L THIS RESULT(PUBL. ONLY IN LINDSEY THESIS)STILL VALID(PRI. COM. LIND.) 11/69*
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients $= \langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3
P 1	.455+-.033		
P 2	-.192	.364+-.034	
P 3	-.666	-.604	.181+-.049

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REFERENCES FOR PHI


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BERTANZA 62 PRL 9 180          BERTANZA,BRISSON,CONNOLLY,HART +  (BNL+SYR)
ARMENTER 63 SIENA CONF 2 70    ARMENTEROS,EDWARDS,ASTIER+ (CERN+CDF-PARIS)
GELFAND  63 PRL 11 438         GELFAND,MILLER,NUSSBAUM,KIRSCH+ (COLU+RUTG)
   GELFAND 63 DATA INCLUDED IN MILLER 65 BELOW
SCHLEIN  63 PRL 10 368         SCHLEIN,SLATER,SMITH,STORK,TICHO     (UCLA)

BADIER   65 PL 17 337          BADIER,DEMOULIN,BARLOUTAUD+ (PAR+LPCHE+ZEE)
BERLEY   65 PR 139 B 1097      D BERLEY,N GELFAND           (BNL+COLUMBIA)
GALTIERI 65 PRL 14 279         A BARBARO GALTIERI,R D TRIPP          (LRL)
LINDSEY  65 PRL 15 221         JAMES S LINDSEY,GERALD A SMITH        (LRL)
   LINDSEY 65 DATA INCLUDED IN LINDSEY 66 BELOW
LINDSEY2 65 UCRL 16526         JAMES S. LINDSEY (THESIS)
MILLER D 65 CU-237(NEVIS 131) DAVID C MILLER  (THESIS)         (COLUMBIA)

GRAY, L  66 PRL  17  501       +HAGERTY,BIZZARRI,CIAPETTI +    (SYR+ROME)JPG
LINDSEY  66 PR  147  913       JAMES S LINDSEY, GERALD A SMITH       (LRL)
LINDSEY1 66 PL 20 93           J.S.LINDSEY, G.A.SMITH                (LRL)
   LINDSEY 1 66 DATA INCLUDED  IN LINDSEY 66 ABOVE
LONDON   66 PR 143 1034        LONDON,RAU,SAMIOS,GOLDBERG + (BNL+SYRACUSE)

ABRAMS   67 MD TECH REP 720    GERALD ABRAMS , THESIS           (MARYLAND)
BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
CHASE    67 PRL 18 710         R.C.CHASE,P.ROTHWELL,R.WEINSTEIN(CEA+NEAST)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)
HERTZBAC 67 PR 155  1461       HERTZBACH,KRAEMER,MADANSKI,ZDANIS+(JHU+BNL)
KHACHATU 67 PL 24B 349         KHACHATURYAN+AZIMOV+BALDIN+BELOUSOV+(DUBNA)

ABRAMS   68 PR 175 1697        +GLASSER,KEHOE,SECHI-ZORN,WOLSKY (MARYLAND)
ASTVACAT 68 PL 27 B  45        ASTVACATUROV,AZIMOV,BALDIN+   (JINR+MOSCOW)
    ALSO 67 PRL 19 869         ASBURY,BECKER,BERTRAM,TING+ (DESY+COLUMBIA)
BECKER   68 PRL 21 1504        +BERTRAM,BINKLEY,JORDAN,KNASEL+  (DESY+MIT)
BINNIE   68 PL 27B 106         +DUANE+FARUQI+HORSEY+     (I.C.LON+RUTHERF)
BOLLINI  68 NC 56 A 1171       +BUHLER,DALPIAZ,MASSAM+     (CERN+BGNA+STRB)
MOSTEK   68 PRL 20 1057        +EISENHANDLER,MCCLELLAN,MISTRY+   (CORNELL)
WEHMANN  68 PRL 20 748         +ENGELS+ (HARVARD+CASE+SLAC+CORNELL+MCGILL)

AUGUSTIN 69 PL 28 B 517        +BIZOT,BUON,DELCOURT,HAISSINSKI+    (ORSAY)
BEMPORAD 69 PL 29 B 383        +BRACCINI,CASTALDI,LUBELSMEYER,+(PISA+BONN)
SCOTTER  69 NC 62 A 1057       +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)
SIDOROV  69  DARESBURY CONF.   V.A.SIDOROV                   (NOVOSIBIRSK)
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$\eta_{0+}(1060)$ $\rightarrow K_S K_S$

3 ETA (1060,JPG=0++)I=0

NAMED S* BY CRENNELL 66.
THE DISAGREEMENT BETWEEN SOME OF THE OBSERVED WIDTHS IS RELATED TO AN AMBIGUITY IN INTERPRETATION OF THIS KS KS PEAK EITHER AS A RESONANCE ABOVE THRESHOLD OR AS A SCATTERING LENGTH EFFECT. FOR POSSIBLE 2 PI MODE, SEE ETA V (1080).

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3 ETA (1060) MASS (MEV)

```
M       (1000.0)   APPROX             BINGHAM   62 HLBC     6-18 PI-N
M       (1000.0)   APPROX             BIGI      62 HBC      10.0 PI-P
M       (1000.0)                      ERWIN     62 HBC      2.10 PI-P       10/66
M     30(1030.0)   APPROX.            BALTAY    64 HBC      3.7 PBAR P
M       (1025.0)   APPROX.            BARMIN    64 HLBC     2.8 PI-P         6/66
M     20 1068.0     10.0              CRENNELL  66 HBC          6.0 PI- P    6/66
M   H  120  SCATT.LENGTH FITS BETTER. HESS      66 HBC      1.6-4.2 PI- P   10/66
M    730 1079.0      6.0       5.0    BEUSCH    67 OSPK    5,7,12 PI-P       9/67
M     54 1030.      10.               ALITTI    68 HBC,DBC  3.6-5.0 K- N     7/69*
M        1065.      10..              PHELAN    68 OSPK    4 PI-P - KS KS N  6/68
M   A   (1045.)    (10.)              PHELAN    68 OSPK    4 PI-P - KS KS N  6/68
M   A   (1035.)    (10.)              PHELAN    68 OSPK    4 PI-P - KS KS N  6/68
M   A    ABOVE 3 VALUES ASSUMING  NO 2PI DECAY, 2PI/KKBAR =1, 2PI/KKBAR=2
M   A    RESPECTIVELY.  SCATTERING LENGTH  (+-1.1 + 0.2*I) F  ALSO FITS.
M        1046.0      7.0              AGUILAR-  69 HBC      0.7,1.2 PBAR P   7/69*
M        AGUILAR 69 SEES INDICATION OF D-WAVE IN ETA(1060) REGION.
M        . . . . . . . . . .
M   AVG  1062.1      8.7      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.5)
                   (SEE IDEOGRAM BELOW )
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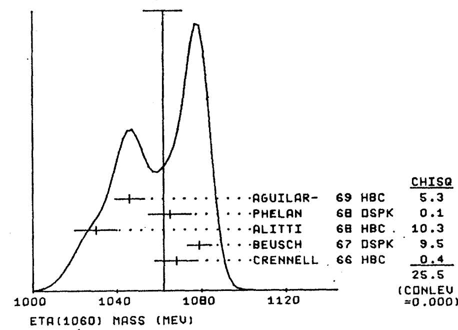
WEIGHTED AVERAGE = 1062.1 ± 8.7
ERROR SCALED BY 2.5



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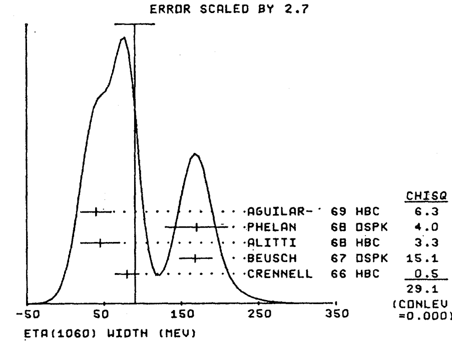
3 ETA (1060) WIDTH (MEV)

```
W     20   80.0     15.0              CRENNELL  66 HBC      6.0 PI-P          6/66
W         168.0     21.0     19.0     BEUSCH    67 OSPK   5,7,12 PI-P         9/67
W     BEUSCH 67 ASSUME NO S WAVE SCATTERING LENGTH. WITH S WAVE THE WIDTH
W     BECOMES NARROWER THAN QUOTED ABOVE.
W     54   45.0     35.0     15.0     ALITTI    68 HBC,DBC 3.6-5.0 K- N       7/69*
W         170.      40.               PHELAN    68 OSPK   4 PI-P - KS KS N   6/68
W   A    (140.)    (50.)    (30.)     PHELAN    68 OSPK   4 PI-P - KS KS N   6/68
W   A    (140.)    (40.)              PHELAN    68 OSPK   4 PI-P - KS KS N   6/68
W          40.0     20.0              AGUILAR-  69 HBC     0.7,1.2 PBAR P    7/69*
W   A     SEE NOTE A UNDER MASS ABOVE.
W         . . . . . . . . . .
W   AVG    90.3     25.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.7)
                   (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 90.3 ± 25.0
ERROR SCALED BY 2.7



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3 ETA (1060) PARTIAL DECAY MODES

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                                                      DECAY MASSES
P1         ETA (1060) INTO KKBAR                      493+ 497
P2         ETA (1060) INTO PIPI                       139+ 134
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Data in parentheses have not been included in our averages.

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                3 ETA (1060) BRANCHING RATIOS

R1        ETA (1060) INTO (PI PI)/(K KBAR)
R1          (2.5)  OR LESS           CRENNELL  66 HBC     90 PCT CONF LEV   7/66
R1           1.0      0.6      0.3   LAI       68 HBC     6 PI- P          11/68

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                         REFERENCES FOR ETA(1060)

BIGI     62 CERN CONF 247      A BIGI,S BRANDT, R CARRARA +          (CERN)
BINGHAM  62 CERN CONF 240      H H BINGHAM,M BLOCH +  (PARIS+EC POLY+CERN)
ERWIN    62 PRL 9 34           ERWIN,HOYER,MARCH,WALKER,WANGLER  (WIS+BNL)

BALTAY   64 DUBNA CONF 1 409   BALTAY,LACH,CRENNELL,OREN,STUMP +(YALE+BNL)
BARMIN   64 DUBNA CONF 1 433   BARMIN,DOLGOLENKO,YEROFEEV,KRESTNI+  (ITEP)

CRENNELL 66 PRL 16 1025        CRENNELL,KALBFLEISCH,LAI,SCARR,SCHU+  (BNL)
HESS     66 PRL 17 1109        +DAHL+HARDY+KIRZ+MILLER               (LRL)
  HESS REPLACES  PRL 9 460     ALEXANDER,DAHL,JACOBS,KALBFLEISCH +   (LRL)

BARLOW   67 NC 50A 701         +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
BEUSCH   67 PL 25 B 357        +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)

ALITTI   68 PRL 21 1705        +BARNES,CRENNELL,FLAMINIC,GOLDBERG,+  (BNL)
HOANG    69 NC 61 A 325        T.F.HOANG                             (ANL)
LAI      68 PHILAD.CONF.P.303  KWAN WU LAI                           (BNL)
PHELAN   68  THESIS            JAMES J. PHELAN        (ANL+ST.LOUIS UNIV)
    ALSO 68 PRL 21 316         HOANG,EARTLY,PHELAN,ROBERTS+(ANL+CHIC+NDAM)

AGUILAR- 69 PL 29 B  241       M.AGUILAR-BENITEZ,J.BARLOW,+     (CERN+CDF)
    ALSO BARLOW 67
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A1(1070)

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10  A1 MESON (1070, JPG=1+-)  I=1
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A_1 Production in Reactions Other Than πp

The A_1 has been seen mainly in the reaction $\pi^{\pm}p \to A_1^{\pm}p$

$$\hookrightarrow \rho^0\pi^{\pm}$$
$$\hookrightarrow \pi^+\pi^-$$

where ambiguities resulting from the presence of the Deck effect complicate the question of its interpretation as a resonance. There has been one experiment, ANDERSON 69, which produced the A_1 in the reaction $\pi^-p \to p\,A_1^-$ in the backward direction, where the Deck effect is not applicable. The A_1 so produced, however, has much steeper u-dependence than exhibited by the other well-known resonances also produced in the same experiment. Moreover this steep $d\sigma/du$ has no simple theoretical explanation. Hence we still accept this striking manifestation of the A_1 with some reservation. It is therefore of interest to look for A_1 peaks in reactions like $\bar{p}p$ and $K^{\pm}p$, where it cannot be diffraction-produced.

• Two $\bar{p}p$ experiments reported seeing the A_1 in $\bar{p}p \to 3\pi^+3^-\pi^0$ (DANYSZ 67 and FRIDMAN 68), where the evidence presented, because of statistics and the shape of the background, is not overwhelming. The facts that 1) it is not seen in simpler final states (e. g., $\bar{p}p \to 2\pi^+2\pi^-\pi^0$) and 2) there are many other $\bar{p}p$ experiments in the same region that have not reported seeing the A_1 make the case for its production in $\bar{p}p$ reactions dubious.

• A_1 production has been reported in <u>two K^-p</u> experiments. At 6 GeV/c ALLISON 67 report a $9 \pm 3\mu b$ $(\pi^+\pi^+\pi^-)$ peak at 1100 MeV in $K^-p \to \Lambda\, 2\pi^+2\pi^-$ and a $15 \pm 5\mu b$ $(\pi^+\pi^+\pi^-)$ peak at 1100 MeV in $K^-p \to \Lambda\, 2\pi^+2\pi^-\pi^0$. In addition to the fact that evidence for the first peak is rather weak, ALLISON 67 state that identification of either peak with the A_1 is open to considerable doubt. At 4.6 and 5.0 GeV/c, JUHALA 67 report an $85 \pm 25\mu b$ $(\rho^{\pm}\pi^{\mp})$ peak at 1060 MeV in the reaction $K^-p \to K^-p\,\rho^{\pm}\pi^{\mp}$, but the statistics are much too poor to conclude anything definite.

• In <u>K^+p</u> interactions there are again two experiments, BERLINGHIERI 69 at 12.8 GeV/c and ALEXANDER 69 at 9.0 GeV/c, which report A_1 production, but there is a much larger experiment, RABIN 69, at 12.0 GeV/c that sets an upper limit of $\sigma(A_1) < 5\mu b$ for high-energy K^+p interactions. A comparison of the various reactions in these three experiments is now tabulated.

The momenta of the two first experiments are so close that we feel that the tentative A_1 peaks of the smaller sample must be considered overwhelmed by the absence of peaks in the larger. As to the ALEXANDER 69 experiment, the A_1 peak is not very clear in any single reaction, and we warn that it is dangerous to combine reactions selectively.

In summary, there is little evidence for A_1 production in reactions other than $\pi^{\pm}p$, especially if we take into account all of the existing experiments in $\bar{p}p$ and $K^{\pm}p$, most of which have null results.

Data in parentheses have not been included in our averages.

Discrepancies in observation of A_1 production in K^+p reactions

$K^+p \rightarrow$	$K_1^0 p \pi^+\pi^+\pi^-$ (A_1^+)	$K_n^0 p \pi^+\pi^+\pi^-$ (A_1^+); K_n: no decay seen	$K^+ p \pi^+\pi^-\pi^0$ (A_1^0)	$K_1^0 p \pi^+\pi^+\pi^-\pi^0$ (A_1^+); A_1^0 (2 combinations)	
Reaction	(1)	(2)	(3)	(4)	
BERLINGHIERI 69, 12.8 GeV/c					
Events compared:	381 in Fig. 1a	Not presented	3497 in Fig. 1b	Not presented	
A_1 events above "background"[a]:	~ 22		~ 130		
$\sigma(A_1)$:	~ 20μb		~ 40μb		
RABIN 69, 12.0 GeV/c			with $\lvert t_{pp}\rvert < 0.3$ GeV^2 to simulate BERLINGHIERI	A_1^+	A_1^0
Events compared:	1454 in Fig. 4a	5434 in Fig. 4d	8685 in Fig. 1b	2647 in Fig. 4b	5294 comb. in Fig. 4c
A_1 events above background:	0	0	0	0	0
$\sigma(A_1)$:	< 5μb	< 5μb	< 5μb	< 5μb	< 5μb
ALEXANDER 69, 9.0 GeV/c	1913 ($K_1 + K_n$) events in Fig. 4 seem to show an A_1 peak.		6812 events in UCRL-18321 show no A_1.	1000 events in Fig. 5b show no A_1	2000 comb. in Fig. 5a. Maybe some A_1^0.

[a]"Background" drawn by authors, not our estimate.

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10  AI MESON  MASS (MEV)

M      MASS AND WIDTH MIGHT HAVE LARGE SYSTEMATIC
M      ERRORS DUE TO COMPLICATED BEHAVIOR OF BACKGROUND.

M   PRODUCED BY PIONS, RESONANCE INTERP. CONFUSED BY DECK EFFECT
M   PRODUCED BY PI +
M        (1080.0)                       ADERHOLZ  64 HBC      4.0 PI+P
M        (1080.)  APPROX.               BOESEBECK 68 HBC  +   8 PI+ P            6/68
M   PRODUCED BY PI -
M        (1060.)                        ASCOLI    68 HBC  -0 5 PI-P              6/68
M         1089.0     12.0               BALLAM    68 HBC  - 16.0 PI- P           9/68
M        (1080.)   APPROX.              CASO      68 HBC  - 11 PI- P             6/68
M        (1090.)   APPROX.              CHUNG     68 HBC  -  3.2,4.2 PI-P        2/67
M         1055.0      6.0               JUNKMANN  68 HBC  -  16. PI- P, 5PI      9/69*
M   S    (1119.)    (30.)               KEY       68 HBC  -  3 PI-P              9/68
M   S     SHOULDER ON A2 ONLY
M        (1079.5)   (10.)               GHMS COLL 69 HBC  -0 11 PI- P            9/69*
M   PRODUCED BY PIONS,BACKWARDS SCATT. NO DECK BUT SURPRISING U-DEPENDENCE
M         1115.0     20.0               ANDERSON  69 MMS  -  16 PI- P,BACKW9     8/69*
M   PRODUCED BY PBARS, SEE TYPED NOTE.
M        (1054.)    (7.)                DANYSZ    67 HBC  +-  3,3.6 PBAR P       7/67
M        (1042.)    (21.)               FRIDMAN   68 HBC  +-  5.7 PBAR P         6/68
M   PRODUCED BY K-, SEE TYPED NOTE.
M         1111.      10.                ALLISON   67 HBC  +   6 K-P,LAM +5 PI    1/68
M         1117.      30.                ALLISON   67 HBC  +   6 K-P,LAM +4 PI    1/68
M         1060.      15.                JUHALA    67 HBC    0 4.6-5 K-P,5BODY    1/68
M   PRODUCED BY K+, SEE TYPED NOTE.
M  K +    1060.0     20.0               ALEXANDER 69 HBC  +    9 K+P             9/69*
M   K+   (1030.0)   (20.0)              BERLINGHI 69 HBC  + 0 12.7 K+ P          9/69*
M   K+ FOR CONTRADICTORY EVIDENCE SEE RABIN 69 AND TYPED NOTE.
M         . . . . . . . . .
M   AVG   1074.0     10.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
                           (SEE IDEOGRAM BELOW )
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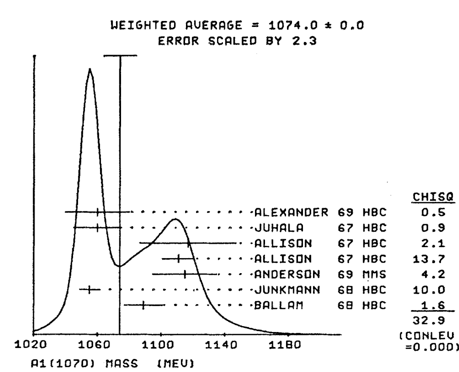

See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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                    10  A1 MESON  WIDTH (MEV)

W       SEE NOTE UNDER A1 MESON MASS.

W     PRODUCED BY PIONS, RESCNANCE INTERP. CONFUSED BY DECK EFFECT
W     PRODUCED BY PI +
W              (80.0)                  ADERHCLZ  64 HBC       4.0 PI+P
W             (130.)   APPROX.         BOESEBECK 68 HBC  +    8 PI+ P          6/68
W     PRODUCED BY PI -
W        306 (146.0)   (18.0)          ABBCH COL 68 HBC  - 16.0 PI- P(3 PI)   9/68
W              140.0     31.0          BALLAM    68 HBC  - 16.0 PI- P          9/68
W             (100.)   APPROX.         CASO      68 HBC  - 11 PI- P            6/68
W             (125.)   APPROX.         CHUNG     68 HBC  -  3.2,4.2 PI-P       2/67
W               77.0     17.0          JUNKMANN  68 HBC  -  16. PI- P, 5PI     9/69*
W     K        (76.)    (46.)          KEY       68 HBC  - 3.0 PI- P          11/67
W     K       SHOULDER ON A2 ONLY
W              (85.0)   (20.0)         GHMS COLL 69 HBC   -0 11 PI- P          9/69*
W     PRODUCED BY PIONS,BACKWARDS SCATT. NO DECK BUT AMAZING V-DEPENDENCE.
W              98.0      45.0    20.0  ANDERSON  69 MMS  -  16 PI- P,BACKW9    8/69*
W     PRODUCED BY PBARS, SEE TYPED NOTE.
W              (33.)     (19.)         DANYSZ    67 HBC  +-  3,3.6 PBAR P      7/67
W             (130.)   APPROX.         FRIDMAN   68 HBC  +-  5.7 PBAR P        6/68
W     PRODUCED BY K-, SEE TYPED NOTE.
W               50.       50.          ALLISCN   67 HBC  +   6 K-P,LAM +4 PI   1/68
W               50.       25.          ALLISCN   67 HBC  +   6 K-P,LAM +5 PI   1/68
W              120.       15.          JUHALA    67 HBC    0 4.6-5 K-P,5BODY   1/68
W     PRODUCED BY K+, SEE TYPED NOTE.
W             (160.0)   (20.0)         ALEXANDER 69 HBC  +    9 K+P            9/69*
W     B       (120.0)   (30.0)         BERLINGHI 69 HBC       12.7 K+ P        8/69*
W     K+ FOR CONTRADICTORY EVIDENCE SEE RABIN 69 AND TYPED NOTE.
W             (130.0)   (20.0)         BERLINGHI 69 HBC  + 0 12.7 K+ P         9/69*
W              . . . . . . . . . .
W     AVG      95.7     13.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                          (SEE IDEOGRAM BELOW )
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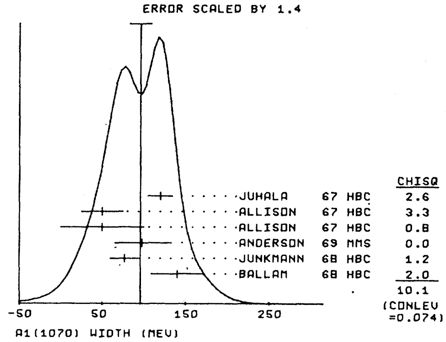
WEIGHTED AVERAGE = 95.7 ± 13.0
ERROR SCALED BY 1.4

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                    10  A1 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      A1 INTO RHO PI                                    765+ 139
P2      A1 INTO KBAR K                                    493+ 497
P3      A1 INTO ETA PI                                    548+ 139
P4      A1 INTO ETA PRIME PI                              957+ 139
P5      A1 INTO 3 PI                                      139+ 139+ 139

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                    10  A1 BRANCHING RATICS

R1      A1 INTO (KBAR K)/(RHO PI)
R1          (0.0025)OR LESS        DAHL      67 HBC   -  4.0 PI- P       10/66
R1      A1 INTO (KBAR K)/(RHO PI)

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                         REFERENCES FOR A1

ADERHCLZ 64 PL 10 226          AACH+BERL+BIRM+BONN+DESY+HAMB+IMP.COL+ MPI

ALLISCN  67 PL 25B 619         +CRUZ+     (OXF+MUN+BIRM+RUTH+GLASG+LON(IC))
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                 (LRL)
DANYSZ   67 NC 51 A 801        DANYSZ+FRENCH+SIMAK                    (CERN)
JUHALA   67 PRL 19 1355        +LEACOCK+RHODE+KOPELMAN+          (ICWA+COLO)

ABBCH CO 68  VIENNA CONF. 466  COLLABORATION AACHEN-BERLIN+BONN+CERN+HEID
ASCOLI   68 PRL 21 113         +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
BALLAM   68 PRL 21 934         +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+   (SLAC)JP
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983        +CONTE+CORDS+DIAZ+    (GENOVA+HAMB+MIL+SACL)
CHUNG    68 PR 165 1491        S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER     (LRL)
FRIDMAN  68 PR 167 1268        +MAURER,MICHALON,CUDET+(HEIDELB+STRASBOURG)
JUNKMANN 68 NP B8 471          +COCCONI+            (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430        +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)

ALEXANDE 69 PR 183 1168        G.ALEXANDER,A.FIRESTONE,G.GOLDHABER    (LRL)
ANDERSON 69 PRL 22 1390        +COLLINS,+                        (BNL+CARN)
BERLINGH 69 PRL 23 42          BERLINGHIERI,FARBER,+                 (ROCH)
GHMS COL 69 LUND CONFERENCE    MAGLIC RVUE            (GENO+HAMB+MILA+SACL)
ROCHESTE 69 LUND CONFERENCE    MAGLIC RVUE                           (ROCH)

                  PAPERS NOT REFERRED TO IN DATA CARDS

BELLINI  63 NC 29 896          BELLINI,FIORINI,HERZ,NEGRI,RATTI     (MILAN)
GOLDHABE 64 PRL 12 336         GOLDHABER,BROWN,KADYK,SHEN,TRILLING(LRL+UC)
LANDER   64 PRL 13 346 A       LANDER,ABOLINS,CARMONY,HENDRICKS +  (UCSD) JP
ABOLINS  65 ATHENS(OHIO)CONF.  +CARMONY,LANDER,XUONG,YAGER      (LA JOLLA)I=1
ALITTI   65 PL 15 69           ALITTI,BATON,DELER,CRUSSARD+        (SAC+BOL)
ALLARD   66 NC 46A 737         +DRIJARD+HENNESSY+   (ORSAY+MILAN+SAC+BERK)
HESS     66 UCRL-16832         R I HESS (THESIS, BERKELEY)             (LRL)
SLATTERY 67 NC 50A 377         +KRAYBILL+FORMAN+FERBEL          (YALE+ROCH)  JP
ARMENISE 68 PL 26 B  336       +FORINC+CARTACCI+         (BARI+BCL+FIR+ORSAY)
CNOPS    68 PRL 21 1609        +HOUGH,COHN,RUGG+ (BNL+ORNL+ORUC+TENN+PENN)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+    (LIVP+OSLO+PADO)
KENYON   69 PRL 23 146         +KINSON,SCARR,+              (BNL+ORUC+ORNL)
MAGLIC   69 LUND CONFERENCE    MAGLIC RVUE                            (RUTG)
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$\eta_V(1080) \to \pi\pi$

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30  ETA V (1080, JPG=V +) I=0  J GREATER THAN 1

    OMITTED FROM TABLE

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                    30  ETA V MASS (MEV)

M          1060.0      15.0              MILLER     68 HBC     4.0 PI- P        9/68
M       70 1085.0      10.0              WHITEHEAD 68 ASPK    3.1-3.6 PI-P    10/67
M          1120.0     100.0     40.0     OH         69 HBC     7.PI- P,PI+ D    9/69*
M      NOTE THAT IN A COMPILATION OF PI N HBC DATA WITH TWICE THE STATISTICS
M      OF WHITEHEADS COMPILATION, NO PI+ PI- PEAK IS SEEN. (P.SCHLEIN 68)
M           . . . . . . . . . .
M    AVG   1077.9      11.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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                    30  ETA V WIDTH (MEV)

W          (70.0)  OR LESS               MILLER     68 HBC     4.0 PI- P        9/68
W          (25.0)  OR LESS               WHITEHEAD 68 ASPK    3.1-3.6 PI-P    10/67
W          150.0     100.0      40.0     OH         69 HBC     7.PI- P,PI+ D    9/69*

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                    REFERENCES FOR ETA V

MILLER   68 PRL 21 1489        +GUTAY,JOHNSON,KENNEY+  (PURDUE+NDAME+SLAC)
SCHLEIN  68  PRIV. COMM.       P.SCHLEIN                            (UCLA)
WHITEHEA 68 NC 53 A 817        C.WHITEHEAD +      (HARWELL+STHAMPT+U.C.LON)
OH       69 PRL 23 331         +WALKER,CARROLL,FIREBAUGH,+      (WISC+TNTO)
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$A_{1.5}(1170)$

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44  A 1.5  (1170, JPG=  -) I=1

BUMP IN 3 PI AND RHO PI MASS SPECTRA BETWEEN A1 AND A2.
EVIDENCE FOR RESONANCE NOT COMPELLING. OMITTED FROM
TABLE.

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                    44  MASS (MEV)

M        (1190.)     (4.)              CASON      67 HBC   -  8 PI-P           6/68
M        (1170.)                       ASCOLI     68 HBC   -0 5 PI-P           6/68
M        (1195.0)   (15.0)             VON KROGH 68 HBC    -  6.7 PI- P        9/68
M         1177.0      8.0              JUNKMANN  68 HBC    -  16. PI- P, 5PI   9/69*

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                    44  WIDTH (MEV)

W         (17.)     (12.)     (6.)     CASCN      67 HBC   -  8 PI-P           6/68
W          45.       15.               ASCOLI     68 HBC   -0 5 PI-P           6/68
W         (20.0)    (10.0)             VON KROGH 68 HBC    -  6.7 PI- P        9/68
W          20.0      10.0              JUNKMANN  68 HBC    -  16. PI- P, 5PI   9/69*
W          . . . . . . . . . .
W    AVG   27.7      11.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

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                    REFERENCES  ON  A 1.5 (1170)

BUTTERWO 67 HEIDELB.CONF.P.28 REVIEW TALK ON MESONS  AT HEIDELBERG CCNF.
CASON    67 PRL 18  880          +LAMSA,BISWAS,DERADO,GROVES,+    (NOTREDAME)
ASCOLI   68 PRL 21 113           +CRAWLEY,KRUSE,MORTARA,SCHAFER,+ (ILLINOIS)
DONALC   68 PL 26 B  327         +FRODESEN,BETTINI,+  (LIVERPOOL,CSLO,PADUA)
VCN KROG 68 PL 27B 253           +MIYASHITA,KOPELMAN,MARSHALL LIBBY   (COLO)
JUNKMANN 68 NP B8 471            +COCCONI+          (AACH+BERL+BONN+CERN+WARS)
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B(1235)

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11  B MESON (1235,JPG=1++) I=1

ASCOLI 68 FIND JP EITHER =1+, OR = 2+,3-,...
BIZZARRI 69 GET GOOD FIT ONLY FOR JP=1+ OR 1-.
THE SERIES JP=3-,5-,...SEEMS UNLIKELY BECAUSE 2PI AND
K KBAR  DECAYS ARE NOT CBSERVED.

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                    11  B MESON  MASS (MEV)

M       60(1220.0)                     ABOLINS   63 HBC  +   3.5 PI+P
M         (1220.0)                     GOLDHABER 65 HBC      3.7 PI+,PI-P
M      376 1200.       20.             BALTAY    67 HBC  +- 0.0 PBAR P         2/67
M       25(1250.)    ESTIMATED         LEE       67 HBC  -   3.6 PI- P         1/68
M          1259.0      27.0            BOESEBECK 68 HBC  +   8.0 PI+ P        10/67
M         (1250.)    APPROX.           CASO      68 HBC  -   11 PI- P          6/68
M          1220.       20.             CHUNG     68 HBC  -  3.2,4.2 PI- P      9/67
M      IN THE 3-4 PI-P DATA,THE B ENHANCEMENT MAY BE DECK EFFECT (CHUNG 68)
M      150(1230.)    APPROX.           GIDAL     68 HBC  +   3-4 PI+ P         6/68
M      300 1245.       10.             BIZZARRI  69 HBC  +-  0 PBAR P          9/69*
M    B      OVERLAPPING B-MESON BANDS TAKEN INTO ACCOUNT BY BIZZARRI
M           . . . . . . . . . .
M    AVG   1235.5      10.5     AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.3)
                          (SEE IDEOGRAM BELOW )

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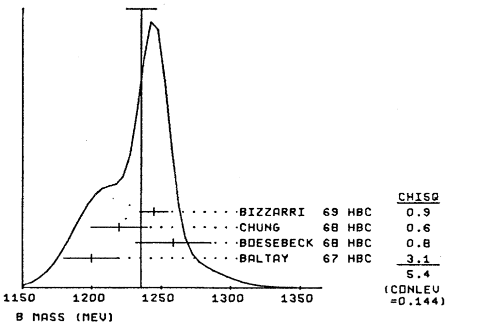
Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1235.5 ± 10.5
ERROR SCALED BY 1.3

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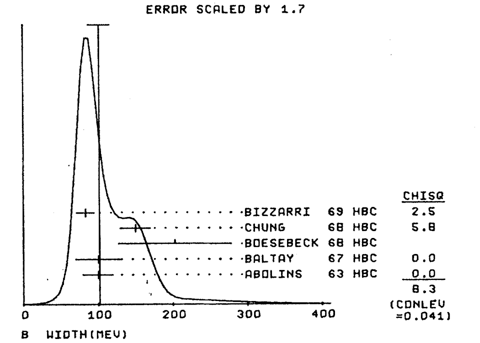
                    11  B MESON  WIDTH (MEV)

W      60  100.0     20.0            ABOLINS   63 HBC  +   3.5 PI+P
W          (80.0)                    GOLDHABER 65 HBC      3.7 PI+,PI-P
W     376  100.      30.             BALTAY    67 HBC  +- 0.0 PBAR P       2/67
W      25 (100.)   ESTIMATED         LEE       67 HBC  -   3.6 PI- P       1/68
W          203.      75.             BOESEBECK 68 HBC  +   8. PI+ P       11/67
W          150.      20.             CHUNG     68 HBC  - 3.2,4.2 PI- P     9/67
W     300   83.      12.             BIZZARRI  69 HBC  +-  0 PBAR P        9/69*
W   B         OVERLAPPING B-MESON BANDS TAKEN INTO ACCOUNT BY BIZZARRI
W           . . . . . . . . .
W   AVG    101.9     14.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                          (SEE IDEOGRAM BELOW )
```

WEIGHTED AVERAGE = 101.9 ± 14.4
ERROR SCALED BY 1.7

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                    11  B MESON PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      B MESON INTO OMEGA+PI                             783+ 139
P2      B MESON INTO 2PI+ 2PI-                            139+ 139+ 139+ 139
P3      B MESON INTO K KBAR                               493+ 493
P4      B MESON INTO PI PI                                139+ 139
P5      B MESON INTO PI PHI                               134+1019
P6      B MESON INTO ETA PI (FORBIDDEN BY G)              548+ 139
P7      B MESON INTO K KBAR PI                            493+ 493+ 139

                    11  B MESON  BRANCHING RATIOS

R1      B INTO  4PI/(OMEGA PI)
R1            (0.5)  OR LESS          ABOLINS   63 HBC  +   3.5 PI+P

R2      B MESON INTO (K KBAR)/(OMEGA PI)
R2            (0.02) OR LESS          DAHL      67 HBC  -   1.6-4.2 PI- P  10/66
R2            (0.10) OR LESS (CL 90)  BALTAY    67 HBC  +-  0.0 PBAR P      2/67
R2            (0.08) OR LESS (CL 95)  BIZZARRI  69 HBC  +-  0 PBAR P        9/69*

R3      B MESON INTO (PI PI)/(PI OMEGA)
R3            (0.3)  OR LESS          ADERHOLZ  64 HBC      4.0 PI+P        7/66

R4      B MESON INTO (PI PHI) / (PI OMEGA)
R4            (0.015)OR LESS          DAHL      67 HBC      1.6-4.2 PI- P  10/66
R4            (0.04) OR LESS (CL 95)  BIZZARRI  69 HBC  +-  0 PBAR P        9/69*

R5      B MESON INTO (ETA PI) / (PI OMEGA)
R5            (0.25) OR LESS (CL 90)  BALTAY    67 HBC  +-  0.0 PBAR P      2/67

R6      B+- INTO ((K KBAR)+- PI0) / (PI OMEGA)
R6            (0.08) OR LESS (CL 90)  BALTAY    67 HBC  +-  0.0 PBAR P      2/67

R6      B+- INTO (KS KS PI+-) / (PI OMEGA)
R6            (0.02) OR LESS (CL 90)  BALTAY    67 HBC  +-  0.0 PBAR P      2/67

R6      B+- INTO (KS KL PI+-) / (PI OMEGA)
R6            (0.06) OR LESS (CL 90)  BALTAY    67 HBC  +-  0.0 PBAR P      2/67

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                         REFERENCES FOR B MESON

ABOLINS  63 PRL 11 381         ABOLINS,LANDER,MEHLHOP,XUONG,YAGER   (UCSD)
ADERHOLZ 64 PL 10 240          AACHEN+BERLIN+BIRM+BONN+HAMBUR+IC-LOND+MPI
GOLDHABE 65 PRL 15 118         G GOLDHABER,S GOLDHABER,KADYK,SHEN     (LRL)

BALTAY   67 PRL 18 93          +SEVERIENS+YEH+ZANELLO              (COL+BNL)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)
LEE      67 PR 159 1156        +MOEBS,ROE,SINCLAIR,VANDERVELDE   (MICHIGAN)

BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983        +CONTE+CORDS+DIAZ+    (GENOVA+HAMB+MIL+SACL)
CHUNG    68 PR 165 1491        S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER     (LRL)
GIDAL    68  UCRL-17984        +BROWN,BIRGE,BACASTOW,FUNG+(LRL+U.C.RIVERS)

BIZZARRI 69  CERN/D.PH. 69-9   +FOSTER,GAVILLET,MONTANET,+       (CERN+CDF)

                    PAPERS NOT REFERRED TC IN DATA CARDS

BONDAR   63 PL 5 209           BONDAR,DODD+ (AACHEN+BIRM+HAMB+IC-LOND+MPI)
CARMONY  64 PRL 12 254         CARMONY,LANDER,RINDFLEISCH,XUONG,YAGER (UC) JP
BALLAM   67 HEIDBG CONF P.33   +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)
SLATTERY 67 NC 50A 377         +KRAYBILL+FORMAN+FERBEL          (YALE+ROCH)
ASCOLI   68 PRL 20 1411        +CRAWLEY,MORTARA,SHAPIRO            (URBANA)  JP
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f(1260)

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          5  F  (1260,JPG=2++)  I=0  .

                    5  F   MASS (MEV)

M          1250.0    25.0          SELOVE    62 HBC      3.0 PI-P
M    J    5(1260.0)                BONDAR    63 HBC      4.0 PI-P          7/69*
M          1260.0    35.0          VEILLET   63 FBC      6.1 PI-P
M         5(1250.0)                GUIRAGOSS 63 HBC      3.3 PI-P
M    J     (1250.0)                LEE       64 HBC      3.7 PI-P          7/69*
M    J     (1270.0)                DERADO    65 HBC      4.0 PI- P         7/69*
M          1240.0    20.0          ACCENSI   66 HBC      5.7 PBAR P        6/66
M       1416 1267.0  10.0          JACOBS    66 HBC    2-3 PI-P,T CUT20   10/67
M          1275.0    25.0          WAHLIG    66 OSPK     10.0 PI-P         6/66
M          (1255.)   (13.)         BARLOW    67 HBC    (K01 K01 MODE)     11/66
M    J     (1271.)   (9.)          EISNER    67 HBC  4.2 PI-P (ALL T)      7/69*
M    J     (1264.)   (7.)          EISNER    67 HBC  4.2 PI-P (T CUT 20)   7/69*
M    J    INCLUDED IN JOHNSON 68
M          (1262.0)  (7.0)         POIRIER   67 HBC      8.0 PI- P        11/67
M    S     (1276.)   (11.)         RABIN     67 HBC      8.5 PI+ P         9/67
M    S      S-WAVE BREIT-WIGNER FIT
M          1261.     4.            ARMENISE  68 DBC      5.1 PI+N,P PI+ -  6/68
M          1270.     5.            ARMENISE  68 DBC      5.1 PI+N,P PI0 0  6/68
M          1265.     8.            BOESEBECK 68 HBC      8 PI+ P           6/68
M          1241.     38.           FOSTER    68 HBC      PBAR P AT REST    6/68
M          1267.     15.           LAMSA     68 HBC      8 PI-P           10/67
M          1268.0    6.0           JOHNSON   68 HBC    0 3.7-4.2 PI- P     7/69*
M          (1270.0)  (15.0)        WHITEHEAD 68 ASPK   3.2 PI-P,PI+PI-N    6/68
M          1255.0    10.0          DONALD    69 HBC      1.2 PB P,2PI      8/69*
M          (1270.0)                CASO      69 HBC      11. PI- P,N2PI    8/69*
M         . . . . . . . . .
M    AVG   1264.3    2.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

                    5  F   WIDTH (MEV)

W          100.0     25.0          SELOVE    62 HBC      3.0 PI-P
W    J   85 (160.0)                BONDAR    63 HBC      4.0 PI-P          7/69*
W          (200.0)  OR LESS        VEILLET   63 FBC      6.1 PI-P
W    J     (130.0)   (20.0)        LEE       64 HBC      3.7 PI-P          7/69*
W    J     (150.0)                 DERADO    65 HBC      4.0 PI- P         7/69*
W    J    INCLUDED IN JOHNSON 68
W          102.0     46.0          ACCENSI   66 HBC      5.7 PBAR P        6/66
W       1416  99.0   10.0          JACOBS    66 HBC    2-3 PI-P,T CUT20   10/67
W          (100.)                  WAHLIG    66 OSPK     10.0 PI-P        11/66
W          (82.)     (34.)         BARLOW    67 HBC    (K01 K01 MODE)     11/66
W    J     (219.)    (39.)         EISNER    67 HBC  4.2 PI-P (ALL T)      7/69*
W    J     (173.)    (25.)         EISNER    67 HBC  4.2 PI-P (T CUT 20)   7/69*
W          (163.0)   (16.0)        POIRIER   67 HBC      8.0 PI- P        11/67
W    S     (155.)    (17.)         RABIN     67 HBC      8.5 PI+ P         9/67
W    S      S-WAVE BREIT-WIGNER FIT
W          216.      13.           ARMENISE  68 DBC      5.1 PI+N,P PI+ -  6/68
W          188.      15.           ARMENISE  68 DBC      5.1 PI+N,P PI0 0  6/68
W          128.      23.           BOESEBECK 68 HBC      8 PI+ P           6/68
W          172.      49.           FOSTER    68 HBC      PBAR P AT REST    6/68
W          113.      30.           LAMSA     68 HBC      8 PI-P           10/67
W          176.0     13.0          JOHNSON   68 HBC    0 3.7-4.2 PI- P     7/69*
W          (160.0)   (20.0)        WHITEHEAD 68 ASPK   3.2 PI-P,PI+PI-N    6/68
W          150.0     30.0          DONALD    69 HBC      1.2 PB P,2PI      8/69*
W          (150.0)                 CASO      69 HBC      11. PI- P,N2PI    8/69*
W         . . . . . . . . .
W    AVG   150.8     15.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.8)
                          (SEE IDEOGRAM BELOW )

                    5  F  PARTIAL DECAY MODES

                                                          DECAY MASSES
P1      F  INTO PI+ PI-                                   139+ 139
P2      F  INTO 2PI+ 2PI-                                 139+ 139+ 139+ 139
P3      F  INTO K KBAR                                    497+ 497

                    5  F   BRANCHING RATIOS

R1      F INTO (2PI+ 2PI-) / TOTAL
R1            0.08     0.06        BONDAR    63 HBC      4.0 PI-P
R1            (0.04) OR LESS       CHUNG     65 HBC      3.2 PI-P
R1            (0.07)               ASCOLI    68 HBC      5 PI- P           6/68
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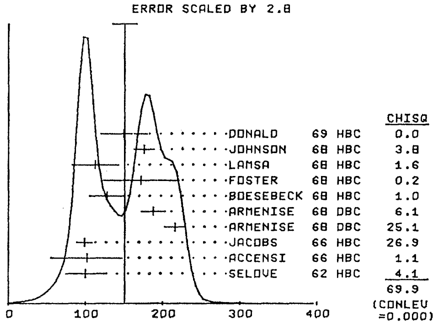
See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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R2       F INTO (K KBAR)/(PI PI)
R2          DETERMINATION DIFFICULT BECAUSE PROXIMITY OF A2 WHICH HAS SAME
R2          NEUTRAL (K KBAR) MODES. SINCE INTERFERENCE MAY BE CONSTRUCTIVE
R2          OR DESTRUCTIVE, EVEN UPPER LIMITS ARE DUBIOUS.
R2            (0.09) OR LESS            BARMIN    65 HLBC     2.8 PI-           10/66
R2            (0.16) OR LESS            WANGLER   65 HBC      3.0 PI-P
R2             PROBABLY SEEN            BARLOW    67 HBC     1.2 PBAR P--K1K1 11/66
R2            (0.047)  (0.012)+ SYST.   BEUSCH    67 OSPK    5,7,12 PI-P        9/67
R2            (0.025)OR LESS            DAHL      67 HBC      1.6-4.2 PI- P    10/66
R2   A        (0.031)  (0.012)          ADERHOLZ  69 HBC      8 PI+ P,K+K-PI-   8/69*
R2   A         K+K- PEAK IS AT ABOUT 1260 MEV WHILE (KKBAR)+ PEAKS AT 1320.
R2   A         ALSO (CROSSSECTION*BRANCHING RATIO) FOR A2 IS SMALL.

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REFERENCES FOR F


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SELOVE   62 PRL 9 272         SELOVE,HAGOPIAN,BRODY,BAKER,LEBOY   (PENNA)
BONDAR   63 PL 5 153          BONDAR+ (AACHEN+BIRM+BONN+DESY+IC-LOND+MPI)
GUIRAGOS 63 PRL 11 85         Z.G.T. GUIRAGOSSIAN                   (LRL)
VEILLET  63 PRL 10 29         VEILLET,HENNESSY,BINGHAM,BLOCH+ (PAR+MILAN)
LEE      64 PRL 12 342        LEE,ROE,SINCLAIR,VANDERVELDE     (MICHIGAN)

BARMIN   65 SJNP 1 623        +DOLGOLENKO+EROFEEV+KRESTNIKOV+ (ITEP MOSC)
CHUNG    65 PRL 15 325        CHUNG,DAHL,HARDY,HESS,JACOBS,KIRZ     (LRL)
DERADO   65 PRL 14 872        DERADO,KENNEY,POIRIER,SHEPHARD (NOTRE DAME)
GUIRAGOS 65 PRL 11 85         Z G T GUIRAGOSSIAN                    (LRL)
WANGLER  65 PR  137 B 414     T P WANGLER,A R ERWIN,W WALKER  (WISCONSIN)

ACCENSI  66 PL 20 557         ACCENSI,ALLES-BORELLI,FRENCH,FRISK+  (CERN)
JACOBS   66 UCRL-16877        L.D.JACOBS,THESIS                     (LRL)
WAHLIG   66 PR  147  941      +SHIBATA,GORDON,FRISCH,MANNELLI  (MIT+PISA) J

BARLOW   67 NC 50A 701        +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
BEUSCH   67 PL 25 B 357       +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
DAHL     67 PR 163 1377       +HARDY+HESS+KIRZ+MILLER               (LRL)
EISNER   67 PR 164 1699       +JOHNSON+KLEIN+PETERS+SAHNI+YEN+   (PURDUE)
POIRIER  67 PR 163 1462       +BISWAS,CASON,DERADO,KENNEY+ (NOTRDAM+PENN)
RABIN    67 THESIS            M. RABIN                          (RUTGERS)

ARMENISE 68 NC 54 A 999       +FORINO+CARTACCI+(BARI+BOLOG+FIRENZE+ORSAY)
ASCOLI   68 PRL 21 1712       G.ASCOLI,H.B.CRAWLEY,D.W.MORTARA,+    (ILL)
BOESEBEC 68 NP B 4 501        BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
FOSTER   68 NP B 6 107        +GAVILLET+LABROSSE+MONTANET+   (CERN+PARIS)
JOHNSON  68 PR 176 1651       +POIRIER,BISWAS,GUTAY,DERADO+(ND+PURD+SLAC)
LAMSA    68 PR 166 1395       +CASON+BISWAS+DERADO+GROVES+    (NOTREDAME)
WHITEHEA 68 NC 53A 817        +MCEWEN,OTT,AITKEN+    (AERE+SHAMPT+UC.LOND)

ADERHOLZ 69 NP B 11 259       +BARTSCH,+         (AACH+BERL+CERN+KRAK+WARS)
CASO     69 NC 62 A 755       +CONTE,BENZ,+      (GENO+DESY+HAMB+MILA+SACL)
DONALD   69 NP B 11 551       +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)

                PAPERS NOT REFERRED TO IN DATA CARDS

HAGOPIAN 63 PRL 10 533        V HAGOPIAN,W SELOVE                 (PENNA)
ADERHOLZ 64 PL 10 240         AACHEN+BERLIN+BIRM+BONN+HAMBUR+IC-LOND+MPI  IJ
BRUYANT  64 PL 10 232         BRUYANT,GOLDBERG,HOLDER,FLEURY,HUC(CERN+PA) I
SODICKSO 64 PRL 12 485        SODICKSON,WAHLIG,MANNELLI,FRISCH+     (MIT) I
BARMIN   65 SJNP 1 230        +DOLGOLENKO,ELENSKY,EROFEEV+  (ITEP MOSCOW)  JP
AGUILAR- 69 PL 29 B  241      M.AGUILAR-BENITEZ,J.BARLOW,+     (CERN+CDF)
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D(1285)

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        8  D MESON (1285,JPG=  +) I=0

        (JP=0-,1+,2- WITH 1+ FAVORED.)

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                8  D MESON  MASS (MEV)

M         (1290.)   APPROX.          BARLOW    67 HBC     1.2 PBAR P, 4PFS   5/67
M          1283.0      5.0           DAHL      67 HBC      1.6-4.2 PI- P    10/66
M          1290.       7.            D.ANDLAU  68 HBC  1.2 PBAR P, 5-6 PFS   6/68
M         (1310.0)                   DEFOIX    68 HBC      1.2 PB P,7 PI     3/69*
M          1270.0     10.0           CAMPBELL  69 DBC      2.7 PI+ D         8/69*
M          1285.       7.            LORSTAD   69 HBC  0.7 PB P, 4,5-BODY    9/69*
M          1329.0     10.0           OTWINCWSK 69 HBC     8 PI+ P, P+6PI     9/69*
M          . . . . . . . . . .
M    AVG   1288.1      7.3    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)
                   (SEE IDEOGRAM BELOW )

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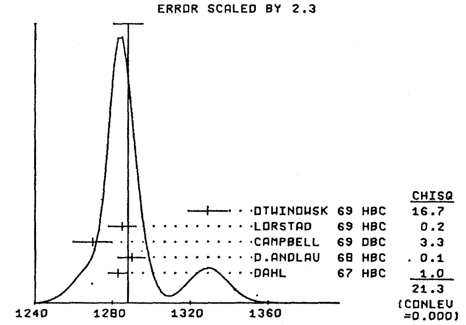


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                8  D MESON WIDTH (MEV)

W          35.0     10.0         DAHL      67 HBC      1.6-4.2 PI- P    10/66
W          30.       5.          D.ANDLAU  68 HBC  1.2 PBAR P, 5-6 PFS   6/68
W         (40.0)                 DEFOIX    68 HBC      1.2 PB P,7 PI     3/69*
W          30.0     15.0         CAMPBELL  69 DBC      2.7 PI+ D         8/69*
W          60.      15.          LORSTAD   69 HBC  0.7 PB P, 4,5-BODY    9/69*
W         (52.0)   (29.0)        OTWINCWSK 69 HBC     8 PI+ P, P+6PI     9/69*
W          . . . . . . . . . .
W    AVG   33.1      4.6    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                8   D MESON PARTIAL DECAY MODES

                                                        DECAY MASSES
P1         D MESON INTO K KBAR PI                     497+ 497+ 134
P2         D MESON INTO PI PI RHO                     134+ 134+ 765
P3         D MESON INTO ETA PI PI                     548+ 134+ 134
P4         D MESON INTO DELTA(962) PI                 962+ 134

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                8  D MESON BRANCHING RATIOS

R1         D MESON INTO (PI PI RHO) / (K KBAR PI)
R1            (2.0)  OR LESS           DAHL      67 HBC     CHARGED PI ONLY 10/66
R1   D        (4.0) OR LESS            DONALD    69 HBC     1.2 PBAR P,5PI   8/69*
R1   D         THIS IS FOR (RHO0 PI+ PI-)/(K KBAR PI0)

R2         D MESON INTO (K KBAR PI)/(ETA PI PI)
R2            (0.124)  (0.035)         DEFOIX    68 HBC     1.2 PB P,7 PI    3/69*

R3         D MESON INTO (DELTA PI)/(ETA PI PI)
R3   D     SEE NOTE UNDER DELTA(962).

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REFERENCES FOR D MESON


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BARLOW   67 NC  50 A  701     +MONTANET,D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
DAHL     67 PR 163 1377       +HARDY+HESS+KIRZ+MILLER            (LRL)I JP
   SEE ALSO 65 PRL 14 1074    MILLER,CHUNG,DAHL,HESS,HARDY,KIRZ+ (LRL+UC)
D.ANDLAU 68 NP  B 5  693      +ASTIER,BARLOW,MONTANET+ (CDF+CERN+RAD+LIV)I JP
DEFOIX   68 PL 28 B 353       +RIVET,SIAUD,CONFORTO,SHIVELY(CDF+IPE+CERN)
CAMPBELL 69 PRL 22 1204       +LICHTMAN,+                          (PURD)
DONALD   69 NP B 11 551       +EDWARDS,BURAN,BETTINI,+   (LIVP+OSLO+PADO)
LORSTAD  69  CERN 69-15 (NP)  B.LORSTAD,D.ANDLAU,ASTIER,+     (CDF+CERN)  JP
OTWINOWS 69 PL 29 B 529       S.OTWINOWSKI                        (WARSAW)
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A2(1300)

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        12  A2 MESON (1300,JPG=2+-)  I=1

        THE MASS AND WIDTH DATA ARE SEPARATED INTO 4 GROUPS
        A2L CONTAINS INFORMATION ON THE LOWER PEAK(3PI,K KBAR)
        A2H CONTAINS INFORMATION ON THE HIGHER PEAK(3PI,KBARK)
        A2K CONTAINS INFORMATION ON K KBAR(UNSPLIT,UNRESOLVED)
        A2 CONTAINS THE REMAINING INFORMATION (NO SEPARATION)

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                12  A2L MESON MASS (MEV)

ML   A     (1274.)    (16.)            CHIKOVANI 67 MMS  -  6,7 PI- P          6/68
ML   A    INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
ML          1289.       5.             BENZ      68 MMS  -  2.65 PI- P        12/68*
ML          1269.0      5.0            CRENNELL  68 HBC  -  6.0 PI-P,X-        6/68
ML          1281.0      3.0            AGUILAR 1 69 HBC +- 0-1.2 PB P,K1K+-    5/69*
ML   AGUILAR 69 COMPIL. INCLUDES BARLOW 67,CONFORTO 67.TWO INCOH.BREITWIGNS
ML   B     (1276.)     (6.)            BAUD      69 MMS  - 7. PI-P, P KKBAR  11/69*
ML   B       FIT TO TWO INCOHERENT BREIT WIGNERS
ML   C     (1289.0)   (10.0)           CRENNELL  69 DBC  -  3.9 K- N,PI-RHO    8/69*
ML   C  MAY BE DIFFERENT OBJECT. JP=1- FAVORED OVER 2+,2-,1+.
ML   C  NOTE THAT IGJP=1-1- IS EXOTIC IN THE QUARK MODEL.
ML          1268.0     12.0            DONALD    69 HBC +-  1.2 PB P(4 PI)     9/69*
ML          . . . . . . . . . .
ML   AVG    1279.7      3.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                    (SEE IDEOGRAM BELOW )
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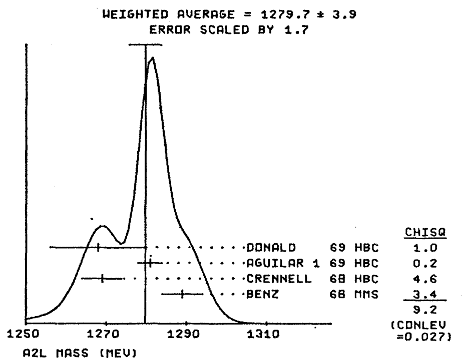
MESON RESONANCES

Data in parentheses have not been included in our averages.

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12  A2H MESON MASS (MEV)

MH  A    (1320.)   (16.)          CHIKOVANI 67 MMS   -  6,7 PI- P         6/68
MH  A   INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
MH        1309.      5.           BENZ      68 MMS   -  2.65 PI- P       12/68*
MH        1315.0     5.0          CRENNELL  68 HBC   -  6.0 PI-P,X-       6/68
MH        1325.0     3.0          AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-   5/69*
MH  AGUILAR 69 COMPIL. INCLUDES BARLOW 67,CONFORTO 67.TWO INCOH.BREITWIGNS
MH  B    (1323.)    (6.)          BAUD      69 MMS   - 7. PI-P, P KKBAR 11/69*
MH  B     FIT TO TWO INCOHERENT BREIT WIGNERS
MH        1324.0    25.0          DONALD    69 HBC  +-  1.2 PB P(4 PI)    9/69*
MH        . . . . . . . . . .
MH  AVG   1319.6     4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                    (SEE IDEOGRAM BELOW )
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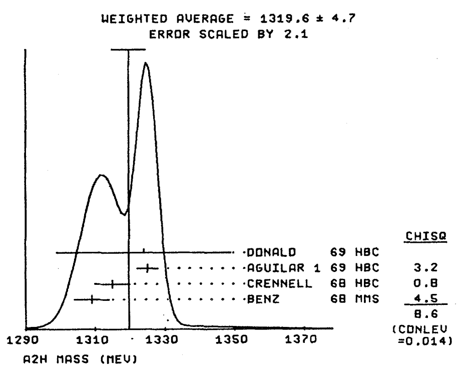


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12  A2  MESON MASS (MEV), K KBAR, UNSPLIT, UNRESOLVED

MK   NOTE THAT NEUTRAL MODE CAN INTERFERE WITH F.
MK     80 1317.0    3.0           BARLOW    67 HBC  +-  1.2 PBAR P, KK    9/67
MK     60 1333.0   13.0           BARLOW    67 HBC  +-  1.2 PBAR P, KK    9/67
MK        1344.0    7.      6.    BEUSCH    67 OSPK   0 5-12 PI-P,K1K1    7/67
MK    130 1280.0   12.0           CONFORTO  67 HBC  +-  0. PBAR P IN KK   9/67
MK        1317.2    4.0           DAHL      67 HBC   -  2.7-4.5 PI- P     8/67
MK        1315.7   10.8           DAHL      67 HBC    0 2.7-4.5 PI- P     8/67
MK        1311.0    5.0           CRENNELL  68 HBC    0 6.0 PI-P,K1K1     6/68
MK     12(1315.0)                 ADERHOLZ  69 HBC  +   8 PI+ P,K+K0      8/69*
MK        . . . . . . . . . .
MK  AVG   1317.9    4.4      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)
                   (SEE IDEOGRAM BELOW )
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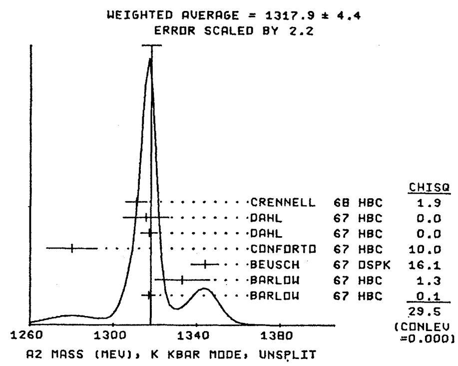
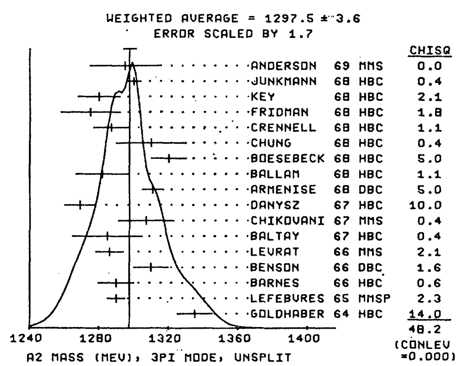
12  A2 MESON MASS (MEV),3PI MODE,SPLITTING UNRESOLVED

M         (1320.0)                ADERHOLZ  64 HBC      4.0 PI+P
M          1335.0   10.0          GOLDHABER 64 HBC  +-  3.7 PI+- P
M      130(1310.0)                FORINO    65 DBC  + 0 4.5 PI+ D        10/66
M     1425 1290.0    5.0          LEFEBVRES 65 MMSP  -  5.6,6.0 PI-P      6/66
M         (1300.0)                SEIDLITZ  65 DBC   -  3.2 PI-D          6/66
M          1290.0   10.0          BARNES    66 HBC   -  6.0 PI-P          6/66
M          1310.0   10.0          BENSON    66 DBC    0 3.65 PI+D         6/66
M     1800(1310.0)  (10.0) COMP.BY FERBEL   66 RVUE +-  PI+- P           10/66
M     1060 1286.     8.           LEVRAT    66 MMS   -   6-7 PI- P        2/67
M      137 1285.    20.           BALTAY    67 HBC    0 8.5 PI+ P         7/67
M   A     (1288.)   (14.)         CASON     67 HBC   -  8 PI- P           5/67
M   A      ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AT 1190 MEV
```




```
M     4000 1307.     16.          CHIKOVANI 67 MMS   -  7 PI- P           8/67
M          1269.      9.          DANYSZ    67 HBC  +-  3,3.6 PBAR P      7/67
M          1311.0     6.0         ARMENISE  68 DBC    0 5.1 PI+D          9/67
M          1282.0    15.0         BALLAM    68 HBC   - 16.0 PI- P         9/68
M          1320.     10.          BOESEBECK 68 HBC    0 8 PI+ P           6/68
M   B     (1280.)   (10.)         BOESEBECK 68 HBC  +   8 PI+ P           6/68
M   B      ASSUMING A1 AND A1.5 MESONS OF FIXED MASS AND WIDTH
M         (1300.)   APPROX.       CASO      68 HBC   - 11 PI- P           6/68
M          1310.     20.          CHUNG     68 HBC   -  2.7-4.5 PI- P     5/68
M          1287.0    10.0         CRENNELL  68 HBC   -  6.0 PI-P,X-       6/68
M          1275.     17.          FRIDMAN   68 HBC  +-  5.7 PBAR P        6/68
M          1280.     12.          KEY       68 HBC   -  3 PI-P           11/67
M         (1301.0)   (8.0)        VON KROGH 68 HBC   -  6.7 PI- P         9/68
M          1300.0     4.0         JUNKMANN  68 HBC   -  16. PI- P, 5PI    9/69*
M          1295.0    20.0         ANDERSON  69 MMS   -  16 PI- P,BACKW9   8/69*
M          . . . . . . . . . .
M   AVG    1297.5     3.6    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                    (SEE IDEOGRAM BELOW )
```




```
12  A2L MESON WIDTH (MEV)

WL  A    (29.)     (10.)          CHIKOVANI 67 MMS   -  6,7 PI- P         6/68
WL  A   INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
WL        22.        5.           BENZ      68 MMS   -  2.65 PI- P       12/68*
WL        24.0      10.0          CRENNELL  68 HBC   -  6.0 PI-P,X-       6/68
WL        22.0      10.0     7.0  AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-   5/69*
WL  AGUILAR 69 COMPIL. INCLUDES BARLOW 67,CONFORTO 67.TWO INCOH.BREITWIGNS
WL  C    (40.0) OR LESS           CRENNELL  69 DBC   -  3.9 K- N,PI-RHO   8/69*
WL  C  MAY BE DIFFERENT OBJECT. JP=1- FAVORED OVER 2+,2-,1+.
WL  C  NOTE THAT IGJP=1-1- IS EXOTIC IN THE QUARK MODEL.
WL         5.0      12.0     5.0  DONALD    69 HBC  +-  1.2 PB P(4 PI)    9/69*
WL        . . . . . . . . . .
WL  AVG   19.2       3.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
```

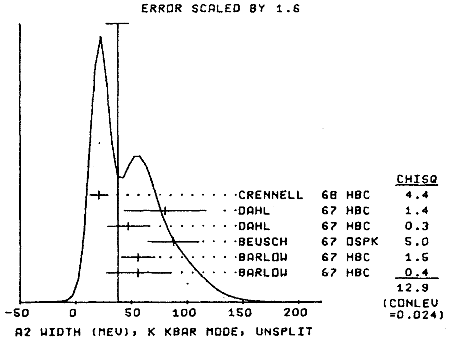
```
12  A2H MESON WIDTH (MEV)

WH  A    (35.)     (10.)          CHIKOVANI 67 MMS   -  6,7 PI- P         6/68
WH  A   INCLUDED IN BENZ 68 FIT OF 2 COHERENT SYMMETRIC POLES.
WH        22.        5.           BENZ      68 MMS   -  2.65 PI- P       12/68*
WH        12.0      10.0          CRENNELL  68 HBC   -  6.0 PI-P,X-       6/68
WH        22.0      10.0     7.0  AGUILAR 1 69 HBC  +- 0-1.2 PB P,K1K+-   5/69*
WH  AGUILAR 69 COMPIL. INCLUDES BARLOW 67,CONFORTO 67.TWO INCOH.BREITWIGNS
WH        21.0      10.0          DONALD    69 HBC  +-  1.2 PB P(4 PI)    9/69*
WH        . . . . . . . . . .
WH  AVG   20.5       3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

Data in parentheses have not been included in our averages.

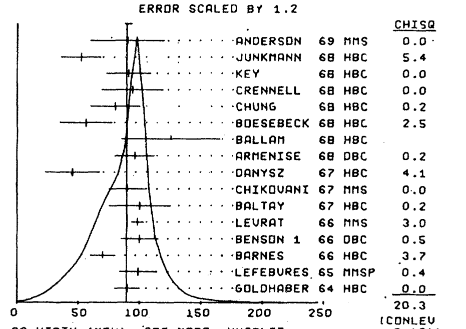
```
                12  A2  MESON WIDTH(MEV), K KBAR, UNSPLIT, UNRESOLVED

WK     NOTE THAT NEUTRAL MODE CAN INTERFERE WITH F.
WK       60  56.0     28.0                BARLOW    67 HBC  +-  1.2 PBAR P, KK    9/67
WK       80  56.0     15.0                BARLOW    67 HBC  +-  1.2 PBAR P, KK    9/67
WK           88.      23.       22.       BEUSCH    67 OSPK   0 5-12 PI-P,K1K1    7/67
WK      130 (90.0)                        CONFORTO  67 HBC  +-  0. PBAR P IN KK   9/67
WK           47.      18.                 DAHL      67 HBC   -  2.7-4.5 PI- P     8/67
WK           80.5     36.5                DAHL      67 HBC   0 2.7-4.5 PI- P     8/67
WK           21.0     10.0       6.0      CRENNELL  68 HBC   -  6.C PI-P,K1K1     6/68
WK       12 (34.0)                        ADERHOLZ  69 HBC   +  8 PI+ P,K+K0      8/69*
WK           . . . . . . . . .
WK  AVG      37.8      9.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)
                      (SEE IDEOGRAM BELOW )
```




```
                12  A2 MESON WIDTH (MEV),3PI MODE,SPLITTING UNRESOLVED

W         (100.0)                          ADERHCLZ  64 HBC       4.0 PI+P
W           90.0     10.0                  GOLDHABER 64 HBC  +-   3.7 PI+- P
W    1425   99.0     15.0                  LEFEBVRES 65 MMSP  -   6.0 PI-P          6/66
W         (140.0)                          SEIDLITZ  65 DBC   -   3.2 PI-D          6/66
W           70.0     10.0                  BARNES    66 HBC   -   6.0 PI-P          6/66
W   N     (110.0)   (45.0)                 BENSON    66 DBC    0 3.65 PI+D          6/66
W   N      SUPERSEDED BY BENSON 1 66
W          100.      15.                   BENSON 1  66 DBC    0 3.65 PI+D          1/67
W    1800  (80.0)   (10.0)    COMP.BY FERBEL       66 RVUE +-   PI+- P             10/66
W    1060   98.       5.                   LEVRAT    66 MMS   -   6,7 PI- P         2/67
W     137  100.      25.                   BALTAY    67 HBC .  0 8.5 PI+ P          7/67
W   A      (84.)    (30.)      (20.)       CASON     67 HBC   -   8 PI- P           5/67
W   A      ANALYSIS COMPLICATED BY NEARBY PEAK (A1.5) AT 1190 MEV
W    4000   90.      15.                   CHIKOVANI 67 MMS   -   7 PI- P           8/67
W           45.      22.                   DANYSZ    67 HBC  +-   3,3.6 PBAR P      7/67
W           96.0     16.0                  ARMENISE  68 DBC    0 5.1 PI+D           9/67
W          125.0     40.0                  BALLAM    68 HBC   - 16.0 PI- P          9/68
W          (90.)    APPROX.                BOESEBECK 68 HBC   +   8 PI+ P           6/68
W           56.      21.                   BOESEBECK 68 HBC    0 8 PI+ P            6/68
W          (80.)    APPROX.                CASO      68 HBC   - 11 PI- P            6/68
W           80.      20.                   CHUNG     68 HBC   -   2.7-4.5 PI- P     5/68
W           94.0     30.0       20.0       CRENNELL  68 HBC   -   6.0 PI-P,X-       6/68
W          (80.)    APPROX.                FRIDMAN   68 HBC  +-   5.7 PBAR P        6/68
W           91.      18.                   KEY       68 HBC   -   3 PI-P           11/67
W          (40.0)   (25.0)                 VON KROGH 68 HBC   -   6.7 PI- P         9/68
W           52.0     16.0                  JUNKMANN  68 HBC   -   16. PI- P, 5PI    9/69*
W           90.0     10.0       50.0       ANDERSON  69 MMS   -   16 PI- P,BACKW9   8/69*
W          . . . . . . . . . .
W   AVG     89.3      3.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)
                             (SEE IDEOGRAM BELOW )
```

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                  12  A2 MESON PARTIAL DECAY MODES

                                                         DECAY MASSES
P1     A2 MESON INTO RHO PI                              765+ 139
P2     A2 MESON INTO KBAR K                              493+ 497
P3     A2 MESON INTO ETA PI                              548+ 139
P4     A2 MESON INTO ETA PRIME PI                        957+ 139
P5     A2 MESON INTO PI+ PI- PI0                         139+ 139+ 134

                  12  A2 MESON  BRANCHING RATIOS

R1      A2 MESON  INTO (K KBAR) / (RHO PI)
R1          (0.08) OR LESS              LANDER    64 HBC  +   3.5 PI+P         10/66
R1  N       (0.13)   (0.03)             BEUSCH    67 OSPK   0 5.7,12 PI-+       9/67
R1      11   0.09     0.06      0.09    ASCOLI    68 HBC  -   5 PI-P            6/68
R1           0.022    0.008             BOESEBECK 68 HBC  +   8 PI+ P           6/68
R1           0.054    0.022             CHUNG     68 HBC  -   3.2 PI-P          1/67
R1           0.03     0.012             DONALD    68 HBC  +-  1.2 PBAR P        6/68
R1  N       (0.14)   (0.05)             BOCKMANN  69 HBC    0 5.0 PI+P          9/69*
R1           0.07     0.05              BOCKMANN  69 HBC  +   5.0 PI+P          9/69*
R1  N  THE NEUTRAL MODE CAN INTERFERE WITH F.
R1           . . . . . . . . .
R1  AVG      0.0281   0.0063   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT      0.0282   0.0058   VALUE FROM CONSTRAINED FIT

R2      A2 MESON INTO (ETA PI)/TOTAL
R2           0.084    0.023             BOESEBECK 68 HBC  +   8 PI+ P           6/68
R2           . . . . . . . . .
R2  FIT      0.116    0.035    VALUE FROM CONSTRAINED FIT

R3      A2 MESON INTO (ETA PI) / (RHO PI)
R3           0.3      0.2               ADERHOLZ  64 HBC      4.0 PI+P
R3  D       (0.24)   (0.08)             DUBCVIKOV 66 HBC  -   3.3 PI-P         11/66
R3  D   VETLITSKY 68 IS UPDATING OF DUBOVIKOV 66
R3           0.22     0.09              CONTE     67 HBC  -   11.0 PI-P         8/67
R3      22   0.23     0.08              ASCOLI    68 HBC  -   5 PI-P            6/68
R3           0.12     0.08              CHUNG     68 HBC  -   3.2 PI-P         12/66
R3          (0.072)OR LESS              DONALD    68 HBC  +-  1.2 PBAR P        6/68
R3           0.16     0.10              KEY       68 HBC  -   3 PI-P           11/67
R3          (0.18)   (0.06)             VETLITSKY 68 HBC  -   3.3 PI- P         9/68
R3      15   0.25     0.09              BOCKMANN  69 HBC  +   5.0 PI+P          9/69*
R3           0.34     0.17      0.34    BOCKMANN  69 HBC    0 5.0 PI+ P         9/69*
R3           . . . . . . . . .
R3  AVG      0.202    0.038    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT      0.136    0.047    VALUE FROM CONSTRAINED FIT

R4      A2 MESON INTO (ETA PRIME PI) / TOTAL
R4          (0.1)  OR LESS              CHUNG     65 HBC  -   3.2 PI-P
R4           0.004    0.004             BOESEBECK 68 HBC  +   8 PI+ P           6/68
R4           . . . . . . . . .
R4  FIT      0.0058   0.0062   VALUE FROM CONSTRAINED FIT

R5      A2 MESON INTO (ETA PRIME PI)/(RHO PI)
R5      14   0.07     0.03              ASCOLI    68 HBC  -   5.0 PI-P          6/68
R5           0.04     0.03      0.04    BOCKMANN  69 HBC    0 5.0 PI+ P         9/69*
R5           . . . . . . . . .
R5  AVG      0.057    0.023    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R5  FIT      0.0068   0.0072   VALUE FROM CONSTRAINED FIT

R6      A2 MESON INTO (PI+ PI- PI0) / (RHO PI)
R6          (0.17) OR LESS              BENSON    66 DBC    0 3.7 PI+D

R7      A2 MESON INTO (ETA PI)/(K KBAR)
R7          (3.0)  OR LESS              FOSTER    68 HBC  -   PBAR P,PBA REST   9/69*
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients $= \langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

```
        P 1        P 2        P 3        P 4

P 1 .854+-.035
P 2   -.114    .024+-.005
P 3   -.968     -.080    .116+-.035
P 4   -.147     -.021     -.013    .006+-.004
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REFERENCES FOR A2


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ADERHCLZ 64 PL 10 248            AACHEN+BERLIN+BIRM+BONN+HAMB+IC-LONDON+MPI
GOLDHABE 64 DUBNA CONF  1 480 G GOLDHABER,S GOLDHABER,OHALLORAN,SHEN(LRL)
LANDER   64 PRL 13 346           +ABOLINS,CARMONY,HENDRIKS,XUONG+ (LA JOLLA)

ABOLINS  65 ATHENS(OHIO)CONF.    +CARMONY,LANDER,XUONG,YAGER     (LA JOLLA)I=1
CHUNG    65 PRL  15  325         +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FORINO   65 PL 19 68             +GESSAROLI+LENDINARA+(BOL+BARI+FIR+ORS+SAC)
LEFEBVRE 65 PL 19 434            CERN MISSING MASS SPECTROMETER GROUP (CERN)
SEIDLITZ 65 PRL 15 217           L SEIDLITZ,O I DAHL,D H MILLER        (LRL)

BARNES   66 PRL 16 41            BARNES,FOWLER,LAI,ORENSTEIN +    (BNL+CCNY)
BENSON   66 PRL 16 1177          G BENSON,LOVELL,MARQUIT,ROE  +   (MICHIGAN)
BENSON 1 66 MICH COO-1112-4      G.C.BENSON, THESIS               (MICHIGAN)
DUBOVIKO 66 PL 23 716+PRIV.C.    DUBOVIKOV,GRIGORIEV,VLADIMIRSKY +    (ITEP)
EHRLICH  66 PR 152 1194          R. EHRLICH,W.SELOVE,H.YUTA   (PENNSYLVANIA)
FERBEL   66 PL 21 111            FERBEL                          (ROCHESTER)
LEVRAT   66 PL  22  714          CERN MISSING MASS SPECTROMETER GROUP (CERN)

ARMENISE 67 PL 25B 53            ARMENISE,FORINO,+        (BARI+BOL+FIR+ORSAY)
BALTAY   67 PL 25B 160           +KIRSCH+KUNG+YEH+RABIN  (COLUM+BNL+RUTGERS)
BARLOW   67 NC 50A 701           +LILLESTOL+MONTANET+(CERN+CDF+IR+LIVERPOOL)
BARTSCH  67 PL 25B 48            +DEUTSCHMANN+GROTE+COCCONI+(AACH+BERL+CERN)
BEUSCH   67 PL 25 B 357          +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
CASON    67 PRL 18 880           +LAMSA,BISWAS,DERADO,GROVES,+   (NOTREDAME)
CHIKOVAN 67 PL 25B 44            CERN MISSING MASS SPECTROMETER GROUP (CERN)
CHUNG    67 PRL 18 100           +DAHL,HARDY,HESS,KIRZ,MILLER          (LRL)
    ALSO 66 UCRL-16832           RICHARD I HESS--THESIS,BERKELEY       (LRL)
COHN     67 NP 81 57             +MCCULLOCH+BUGG+CONDO      (ORNL+UNIV.TENN.)
CONFORTO 67 NP 83 469            +MARECHAL,MONTANET+ (CERN+CF+IPN+LIVERPOOL)
CONTE    67 NC   51 A  175       +TOMASINI,CORDS+ (GENOVA+HAM+MILANC+SACLAY)
DAHL     67 PR 163 1377          +HARDY+HESS+KIRZ+MILLER               (LRL)
DANYSZ   67 NC 51 A 801          DANYSZ+FRENCH+SIMAK                  (CERN)

ARMENISE 68 PL 26B 336           ARMENISE,FORINO,+        (BARI+BOL+FIR+ORSAY)
ASCOLI   68 PRL 20  1321         +CRAWLEY,MORTARA,SHAPIRO,BRIDGES+(ILLINOIS)
BALLAM   68 PRL 21 934           +BRODY,CHADWICK,FRIES,GUIRAGOSSIAN+  (SLAC)
BOESEBEC 68 NP B 4 501           BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68 NC 54 A 983          +CONTE+COROS+DIAZ+    (GENOVA+HAMB+MIL+SACL)
CHUNG    68 PR 165 1491          S.U.CHUNG,O.DAHL,J.KIRZ,D.H.MILLER    (LRL)
CRENNELL 68 PRL 20 1318          +KARSHON+KWAN LAI,SCARR,SKILLICORN    (BNL)
DONALD   68 PL 26 B  327         +FRODESEN+BETTINI+    (LIVERPOOL+OSLO+PADUA)
FOSTER   68 NP B 8 174           +GAVILLET,LABROSSE,MONTANET,+   (CERN+CDEF)
FRIDMAN  68 PR 167 1268          +MAURER,MICHALON,OUDET+(HEIDELB+STRASBOURG)
JUNKMANN 68 NP B8 471           +COCCONI,+          (AACH+BERL+BONN+CERN+WARS)
KEY      68 PR 166 1430          +PRENTICE+COOPER+MANNER+WALKER+(TO+ANL+WIS)
VETLITSK 68  VIENNA CONF.        VETLITSKY,GRIGOREYEV,GRISHIN,GUZHAVIN+(ITEP)
VON KROG 68 PL 27 B 253          +MIYASHITA,KOPELMAN,MARSHALL LIBBY   (COLO)
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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ADERHOLZ 69 NP B 11 259        +BARTSCH,+        (AACH+BERL+CERN+KRAK+WARS)
AGUILAR 169 PL 29 B  62        +BARLOW,JACOBS,DELLA NEGRA+(CERN+CDF +LIVP)
AGUILAR 269 PL 29 B  241       M.AGUILAR-BENITEZ,J.BARLOW,+      (CERN+CDF)
ANDERSON 69 PRL 22 1390        +COLLINS,+                        (BNL+CARN)
BAUD     69 CERN PREPRINT      +BENZ,BOSNJAKOVIC,BOTTERILL,DAMGAARD+(CERN)
BOCKMANN 69  PREPRINT          +MAJOR,POLS,+     (BONN+DURH+NIJM+EPOL+TORI)
BENZ     68 PL 28 B 233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
CHIKOVAN 69 PL 28 B  526       CERN MISSING MASS SPECTROMETER GROUP (CERN) JP
CRENNELL 69 PRL 22 1327        +KARSHON,KWAN WU LAI,+                (BNL)IJP
DONALD   69 NP B 12 325        +EDWARDS,FOSTER,MOORE             (LIVERPOOL)

                 PAPERS NOT REFERRED TO IN DATA CARDS

LANDER   64 PRL 13 346 A       LANDER,ABOLINS,CARMONY,HENDRICKS +   (UCSD)  JP
ADERHCLZ 65 PR 138 B 897       AACHEN+BERLIN+BIRM+BONN+HAMB+LOND+MUENCHEN
ALITTI   65 PL 15 69           ALITTI,BATON,DELER,CRUSSARD+ (SACLAY+BOLOG)  JP
SLATTERY 67 NC 50A 377         +KRAYBILL+FORMAN+FERBEL          (YALE+ROCH)  JP
LAMSA    68 PR 166 1395        +CASON+BISWAS+DERADO+GROVES+     (NOTREDAME)

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$A2_{I=2}(1320)$

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37  A2,2 (1320) I=2 OR GREATER

SEEN AS A BUMP IN RHO- PI- MASS SPECTRUM.
EVIDENCE NOT COMPELLING. CMITTED FROM TABLE.
FOR A DISCUSSION SEE ROSENFELD 68

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                 37 MASS (MEV)

M       34 1320.     25.          VANDERHAG 67 DBC  -- 5 PI-D          5/67

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                 37 WIDTH (MEV)

W       34 (150.)  APPROX.        VANDERHAG 67 DBC  -- 5 PI-D          5/67

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                 37 CROSS SECTION (MICROBARNS)

CS      34  15.      5.           VANDERHAG 67 DBC  -- 5 PI-D          5/67

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                      REFERENCES FOR A2,2

VANDERHA 67 PL 24B 493         VANDERHAGEN+HUC+FLEURY+ (EP+IPN+BARI+BOLOG)
ROSENFEL 68 PHILA.CONF.455     A.H.ROSENFELD                          (LRL)

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E(1422)

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6  E MESON  (1422,JPG=A +)  I=0

BAILLON 67 FAVOR JP=0-. DAHL 67 FAVOR 1+ BUT DO NOT
EXCLUDE 2-, 0-. LORSTAD 69 FIND 0- OR 1+.

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                 6 E MESON MASS (MEV)

M          1425.       7.           BAILLON   67 HBC     0. PBAR P       11/66
M          1420.0     20.0          DAHL      67 HBC     1.6-4.2 PI- P   10/66
M          1423.      10.           FRENCH    67 HBC     3-4 PBAR P       6/67
M      310 1420.       7.           LORSTAD   69 HBC  0.7 PB P, 4,5-BODY  9/69*
M          . . . . . . . . . . .
M   AVG    1422.5      4.3     AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.0)

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                 6 E MESON WIDTH (MEV)

W            80.      10.           BAILLON   67 HBC     0. PBAR P       11/66
W            60.0     20.0          DAHL      67 HBC     1.6-4.2 PI- P   10/66
W            45.      20.           FRENCH    67 HBC     3-4 PBAR P       6/67
W      310   60.      20.           LORSTAD   69 HBC  0.7 PB P, 4,5-BODY  9/69*
W          . . . . . . . . . . .
W   AVG      69.3      7.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 6 E MESCN PARTIAL DECAY MODES

                                                          DECAY MASSES
P1         E INTO K K*(890)                              493+ 892
P2         E INTO K KBAR PI                              497+ 497+ 139
P3         E MESON INTO PI PI RHO                        134+ 134+ 765
P4         E INTO PI(1016) PI                           1016+ 139
P5         E INTO ETA PI PI                              548+ 139+ 139

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                 6  E MESCN BRANCHING RATIOS

R1         E INTO K K*(890)/((K K*)+(PI(1016) PI))
R1            .50      .10          BAILLON   67 HBC      0.0 PBAR P     11/66

R2         E MESON INTO (PI PI RHO) / (K KBAR PI)
R2           (2.0)  OR LESS         DAHL      67 HBC   0 CHARGED PI ONLY 10/66

R3     E MESON INTO (ETA 2 PI)/(K KBAR PI)
R3           (1.5)OR LESS (CL=0.95)  FOSTER    68 HBC  -  PBAR P,PBA REST  9/69*

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                       REFERENCES FOR E MESON

BAILLON  67 NC 50A  393        +EDWARDS+D.ANDLAU+ASTIER+      (CERN+CDF+IR)
BARASH   67 PR 156  1399       BARASH,KIRSCH,MILLER,TAN          (COLUMBIA)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER               (LRL)I JP
   SEE ALSO 65 PRL 14 1074     MILLER,CHUNG,DAHL,HESS,HARDY,KIRZ+ (LRL+UC)
FRENCH   67 NC 52A 438         +KINSON+MCDONALD+RIDDIFORD+      (CERN+BIRM)
FOSTER   68 NP B 8 174         +GAVILLET,LABROSSE,MONTANET,+    (CERN+CDEF)
BETTINI  69 NC 62 A 1038       +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)IC
LORSTAD  69  CERN 69-15 (NP)   B.LORSTAD,D.ANDLAU,ASTIER,+       (CDF+CERN)  JP

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$K_S K_S(1440)$ / $\rho\rho(1410)$

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29  KSKS(1440) AND RHORHO(1410) (JPG=V +) I GTE 0

EVIDENCE NOT YET COMPELLING, OMITTED FROM TABLE.
IF RHOO RHOO AND KS KS ARE MODES OF THE SAME RESONANCE
THEN I=0.

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                 29  KSKS AND RHORHO MASS  (MEV)

M   -------RHOO RHOO MODE-------
M        (1410.0)                   BETTINI   66 DBC   0  0. PBARP TO 5PR  9/66

M   -------KS KS MODE ----------
M   B    POSSIBLY SEEN              ABRAMS    67 HBC     4.25 K- P          5/67
M   B    THE AUTHORS ASSOCIATE THE PEAK WITH THE F PRIME, BUT BACKGROUND .
M   B    ESTIMATION IS DIFFICULT
M        1412.      23.             BARLOW    67 HBC     1.2 PBAR P         5/67
M        1439.0      5.0     6.0    BEUSCH    67 OSPK    5,7,12 PI-P        9/67
M        . . . . . . . . . . .
M   AVG  1437.5      5.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 29  KSKS AND RHORHO WIDTH (MEV)

W   -------RHOO RHOO MODE-------
W         (90.0)                    BETTINI   66 DBC   0 0. PBAR P TO 5PR  9/66

W   -------KS KS MODE ----------.
W         100.      70.             BARLOW    67 HBC     1.2 PBAR P         5/67
W          43.0     17.0     18.0   BEUSCH    67 OSPK    5,7,12 PI-P        9/67
W        . . . . . . . . . . .
W   AVG    46.4     17.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                REFERENCES FOR KSKS(1440) AND RHC RHO(1410)

BETTINI  66 NC 42A 695         +CRESTI,LIMENTANI,LORIA,PERUZZO+ (PAD+PISA)
ABRAMS   67 PRL 18 620         +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
BARLOW   67 NC  50 A  701      +MONTANET,D-ANDLAU+(CERN+CDF+IDR+LIVERPOOL)
BEUSCH   67 PL 25 B 357        +FISCHER,GOBBI,ASTBURY,MICHELINI+(ETH+CERN)
DONALD   69 NP B 11 551        +EDWARDS,BURAN,BETTINI,+    (LIVP+OSLO+PADO)

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f′(1514)

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13  F PRIME (1514,JPG=2++)  I=0

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                 13  F PRIME(1514) MASS (MEV)

M        14(1480.0)                 CRENNELL  66 HBC      6.0 PI- P         8/66
M   B     5(1460.)    (10.)         ABRAMS    67 HBC     4.25 K- P          5/67
M   B    BACKGROUND ESTIMATION DIFFICULT.                                   5/67
M           1515.0     7.0          AMMAR     67 HBC      5.5 K-P           9/67
M        70 1513.0     7.0          BARNES    67 HBC     4.6, 5. K- P      10/67
M          . . . . . . . . . . .
M   AVG     1514.0     4.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 13  F PRIME(1514) WIDTH (MEV)

W   B     5  (53.)    (18.)         ABRAMS    67 HBC     4.25 K- P          5/67
W   B    BACKGROUND ESTIMATION DIFFICULT.                                   5/67
W            35.0     25.0          AMMAR     67 HBC      5.5 K-P           9/67
W        70  87.0     15.0          BARNES    67 HBC     4.6, 5. K- P      10/67
W          . . . . . . . . . . .
W   AVG      73.2     22.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.8)

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                 13  F PRIME PARTIAL DECAY MODES

                                                         DECAY MASSES
P1         F PRIME INTO PI+ PI-                          139+ 139
P2         F PRIME INTO K KBAR                           497+ 497
P3         F PRIME INTO K K*(890)                        493+ 892
P4         F PRIME INTO ETA ETA                          548+ 548
P5         F PRIME INTO PI PI ETA                        139+ 139+ 548
P6         F PRIME INTO PI K KBAR                        139+ 497+ 497

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                 13  F PRIME BRANCHING RATIOS

R1         F PRIME INTO (PI+ PI-)/(K KBAR)
R1           (0.2)  OR LESS         AMMAR.    67 HBC     5.5 K-P ,CL=.67  9/67
R1           (0.18) OR LESS         BARNES    67 HBC     4.6, 5.0 K- P    10/67

R3         F PRIME INTO (ETA ETA)/(K KBAR)
R3           (0.50) OR LESS         BARNES    67 HBC     4.6, 5.0 K- P    10/67

R4         F PRIME INTO (PI PI ETA)/(K KBAR)
R4           (0.3)  OR LESS         AMMAR     67 HBC     CL=0.67          10/67
R4            0.25     0.13         BARNES    67 HBC     4.6, 5.0 K- P    10/67

R5         F PRIME INTO (PI K KBAR + K K*(890))/(K KBAR)
R5           (0.4)  OR LESS         AMMAR     67 HBC     CL=0.67          10/67
R5           (0.14) OR LESS         BARNES    67 HBC     4.6, 5.0 K- P    10/67
R5  B     OR AS 0.14    0.14        BARNES    67 HBC     4.6, 5.0 K- P    10/67

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                       REFERENCES FOR F PRIME

CRENNELL 66 PRL  16  1025      + KALBFLEISCH,LAI,SCARR,SCHUMANN +     (BNL)I
ABRAMS   67 PRL 18 620         +KEHOE,GLASSER,SECHI-ZORN,WOLSKY (MARYLAND)
AMMAR    67 PRL  19  1071      +DAVIS,HWANG,DAGAN,DERRICK +      (NWU+ANL)  JP
BARNES   67 PRL  19  964       +DORNAN,GOLDBERG,LEITNER +   (BNL+SYRACUSE)ICJP
ALITTI   68 PRL 21 1705        +BARNES,CRENNELL,FLAMINIO,GOLDBERG,+  (BNL)
LORSTAD  69  CERN 69-15 (NP)   B.LORSTAD,D.ANDLAU,ASTIER,+        (CDF+CERN)
SCOTTER  69 NC 62 A 1057       +ERSKINE,PALER,+  (BIRM+GLAS+LOIC+MPIM+OXF)

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Data in parentheses have not been included in our averages.

$\pi/\rho(1540)$ "F_1" $\rightarrow K^*\bar{K}$

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47  PI/RHO (1540,JPG=    ) I=1

NAMED F1 BY AGUILAR 69
JP=2-,1+ FAVORED, 0- LESS PROBABLE.

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                 47  PI/RHO (1540)   MASS (MEV)

M       10(1490.0)   (20.0)          ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI 11/69*
M      142 1540.0      5.0           AGUILAR   69 HBC     0.7PBARP,KKBARPI 11/69*

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                 47  PI/RHO (1540)  WIDTH (MEV)

W       10  (85.0)   (39.0)          ADERHOLZ  69 HBC  +   8 PI+ P,KKBARPI 11/69*
W      142   40.0     15.0           AGUILAR   69 HBC     0.7PBARP,KKBARPI 11/69*

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                 47  PI/RHO (1540)  PARTIAL DECAY MODES

                                                              DECAY MASSES
P1          PI/RHO (1540) INTO K KBAR PI                     134+ 497+ 497
P2          PI/RHO (1540) INTO K*(890) KBAR                  892+ 497

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                              REFERENCES FOR PI/RHO (1540)

ADERHOLZ 69 NP B 11 259          +BARTSCH,+         (AACH+BERL+CERN+KRAK+WARS)
AGUILAR  69 PL 29 B 379          +BARLOW,JACOBS,D ANDLAU,ASTIER+ (CERN+CDEF)
AGUILAR1 69  CERN 69-11          +BARLOW,JACOBS,D ANDLAU,ASTIER+ (CERN+CDEF)

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$\pi_A(1640)$ $\rightarrow 3\pi$

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34  PI (1640, JPG=A -)  I = 1

(ALSO CALLED A3.)
THIS ENTRY CONTAINS G=-1 PEAKS AND THE R1 PEAK.
BARTSCH 68 FIND BEST FIT WITH JP=2-.NEXT BEST 1+,0-,3+

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                 34  PI (1640) MASS  (MEV)

M        30(1600.0)                   FORINO    65 DBC    04.5 PI+ D       10/66
M        20 1630.0      30.0          VETLITSKY 66 HBC  -  4.7 PI- P
M   O      (1689.)     (10.)          DANYSZ    67 HBC   0 3,3.6 PBAR P    7/67
M   O    OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
M   O    NOTE THAT THE WIDTH OF THIS PEAK IS SMALL
M   R      (1630.)     (15.)          DUBAL     67 MMS  -  7,11.5,12PI- P  7/67
M   R    R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
M   R    NOTE THAT THE R1 HAS SMALLER WIDTH THAN THE OTHER ENTRIES.
M          1630.       10.            BALTAY    68 HBC  +  7, 8.5 PI+ P    6/68
M          1660.0      16.0           BARTSCH   68 HBC  +  8. PI+ P,3PI P  8/69*
M         (1660.)                     CASO 1    68 HBC  -  11 PI- P        6/68
M         (1680.0)                    CASO 1    68 HBC  -  11 PI-P, PI-F   6/68
M         (1650.0)                    IOFFREDO  68 HBC  - 13-20 PI-P,PI-F  9/68
M          1610.       19.            LAMSA     68 HBC  -  8.0 PI-P, PI-F 11/67
M   Q     (1670.0)    (18.0)          YOST      68 HBC   04.3 K-P,LMBD.5PI  9/68
M   O      OBSERVED IN (OMEGA PI+ PI-) BUT NOT IN (OMEGA RHO 0)
M   P     (1695.0)    (20.0)          BARNES    69 HBC   0 4.6 K-P,OMEG2PI 8/69*
M   P    OBSERVED IN (OMEGA PI+PI-) AND (OMEGA RHO0) MODES IN RATIO 2/1
M          . . . . . . . . . .
M   AVG    1633.5      9.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                 34  PI (1640) WIDTH  (MEV)

W   R      (21.)   OR LESS            LEVRAT    66 MMS  -  7,12 PI- P      7/67
W   R    R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
W        20 (100.)                    VETLITSKY 66 HBC  -  4.7 PI-P        6/66
W   O      (38.)      (18.)           DANYSZ    67 HBC   0 3,3.6 PBAR P    7/67
W   O    OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
W          70.        40.             BALTAY    68 HBC  +  7, 8.5 PI+ P    6/68
W          115.0      45.0            BARTSCH   68 HBC  +  8. PI+ P,3PI P  8/69*
W         (130.)                      CASO 1    68 HBC  -  11 PI- P        6/68
W         (150.0)                     CASO 1    68 HBC  - 11.0 PI-P,PI- F  6/68
W          100.       50.       30.   LAMSA     68 HBC  -  8.0 PI-P  PI-F 11/67
W   Q     (50.0)     (15.0)           YOST      68 HBC   04.3 K-P,LMBD.5PI  9/68
W   Q      OBSERVED IN (OMEGA PI+ PI-) BUT NOT IN (OMEGA RHO 0)
W   P     (80.0)                      BARNES    69 HBC   0 4.6 K-P,OMEG2PI 8/69*
W   P    OBSERVED IN (OMEGA PI+PI-) AND (OMEGA RHO0) MODES IN RATIO 2/1
W          . . . . . . . . . .
W   AVG     93.5      23.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 34  PI (1640) PARTIAL DECAY MODES

                                                              DECAY MASSES
P1          PI(1640) INTO 3 PI                               134+ 134+ 134
P2          PI(1640) INTO RHO PI                             134+ 765
P3          PI(1640) INTO ETA PI                             134+ 548
P4          PI(1640) INTO 5 PI
P5          PI(1640) INTO K K*(890)                          497+ 892
P6          PI(1640) INTO K KBAR PI                          497+ 497+ 134
P7          PI(1640) INTO K KBAR                             497+ 497
P8          PI(1640) INTO F PI                              1264+ 134
P9          PI(1640) INTO OMEGA PI PI                        783+ 134+ 134

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                 34  PI (1640)  BRANCHING RATIOS

R2          PI(1640)+- INTO (PI+- RHO0)/(ALL PI+- PI+ PI-)
R2            (0.2) OR LESS           BALTAY    68 HBC  +  7-8.5 PI+P      5/68
R2            (0.3) OR LESS           BARTSCH   68 HBC  +  8. PI+ P,3PI P  8/69*
R2  C         (0.35)OR LESS           CASO 1    68 HBC  - 11.0 PI-P        6/68
R2  C     CASO 2 68 IS UPDATING OF CASO 1 68
R2            (0.03)    (0.36)   (0.03) CASO 2  68 HBC  - 11.0 PI- P       9/68
R2             CONSISTENT WITH 0.0    IOFFREDO  68 HBC  - 13-20 PI-P       9/68

R3          PI(1640)+- INTO (PI+- F)/(ALL PI+- PI+ PI-)
R3                    (WITH F INTO PI+ PI-)
R3             INDICATION SEEN        LUBATTI   66 HLBC    16 PI-         11/66
R3            (0.59)FOR JP=2-         BARTSCH   68 HBC  +  8. PI+ P,3PI P  8/69*
R3            (0.51)FOR JP=1+         BARTSCH   68 HBC  +  8. PI+ P,3PI P  8/69*
R3            (0.20)FOR JP=0-         BARTSCH   68 HBC  +  8. PI+ P,3PI P  8/69*
R3             0.35      0.20         BALTAY    68 HBC  +  7-8.5 PI+P      5/68
R3  C          CONSISTENT WITH 1.0    CASO 1    68 HBC  -  11 PI- P        6/68
R3  C     CASO 2 68 IS UPDATING OF CASO 1 68
R3            (0.94)    (0.06)   (0.29) CASO 2  68 HBC  - 11.0 PI- P       9/68
R3          SEEN                      IOFFREDO  68 HBC  - 13-20 PI-P,PI-F  9/68

R4          R1 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R4            (0.37)/   0.59 /   0.04 FOCACCI   66 MMS  -  3-12 PI-P      10/66

R5          PI(1640) +- INTO (PI+- ETA)/(ALL PI+- PI+ PI-)
R5                    (ALL ETA DECAYS)
R5            (0.09)OR LESS           BALTAY    68 HBC  +  7-8.5 PI+P      5/68

R6          PI(1640)+- INTO (PI+- 2PI+ 2PI-)/(ALL PI+- PI+ PI-)
R6            (0.1) OR LESS           BALTAY    68 HBC  +  7,8.5 PI+ P     6/68

R7          PI(1640) INTO (OMEGA PI PI)/(F PI)
R7  P          (4.)  OR GREATER       BARNES    69 HBC   0 4.6 K-P,OMEG2PI 8/69*
R7  P NOT CLEAR IF (OMEGA PI+PI-) PEAK IS DECAY MODE OF PI(1640)

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                              REFERENCES FOR PI(1640)

FORINO   65 PL 19 68             +GESSAROLI+LENDINARA+(BOL+BARI+FIR+ORS+SAC)
FOCACCI  66 PRL  17  890         CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL  22  714          CERN MISSING MASS SPECTROMETER GROUP (CERN)
LUBATTI  66 THESIS BERKELEY      H.J.LUBATTI                          (LRL)1-2-
VETLITSK 66 PL  21  579          VETLITSKY,GUSZAVIN,KLIGER,ZOLGANOV+  (ITEP)

DANYSZ   67 NC 51 A 801          DANYSZ+FRENCH+SIMAK                  (CERN)
DUBAL    67 NP B3 435            CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456          L.DUBAL                              (GENEVE)

BALTAY   68 PRL 20 887           +KUNG+YEH+FERBEL+    (CCLMB+ROCH+RUTG+YALE)I=1
BARTSCH  68 NP B 7 345           +KEPPEL,KRAUS,+              (AACH+BERL+CERN) JP
CASO 1   68 NC 54 A 983          +CONTE+CORDS+DIAZ+    (GENOVA+HAMB+MIL+SACL)
CASO 2   68  VIENNA CONF.        +CONTE,CORDS,PATTI+ (GENOA+HAMB+MILAN+SACL)
FERBEL   68 PHILA.CONF.335       T.FERBEL                          (ROCHESTER)
IOFFREDO 68 PRL 21 1212          +BRANDENBURG,BRENNER,EISENSTEIN+  (HARVARD)
LAMSA    68 PR 166 1395          +CASON+BISWAS+DERADC+GROVES+      (NOTREDAME)
YOST     68  UMD  T.REPORT849    +YODH,EINSCHLAG,DAY,GLASSER             (UMD)

BARNES   69 PRL 23 142           +CHUNG,EISNER,FLAMINIO,+                (BNL)

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$\phi(1650)$ $\rightarrow \rho^0\pi^0$

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45  PHI (1650,JPG=  -) I=0

OMITTED FROM TABLE
THIS ENTRY CONTAINS NEUTRAL 3 PI ENHANCEMENTS FOR WHICH
A (RHO 0 PI 0) DECAY MODE, AND THEREFORE I=0, HAS BEEN
SUGGESTED.  PRESENT EVIDENCE LOOKS GOOD BUT STATISTICS
IS NOT YET SUFFICIENT TO REGARD I=0 AS ESTABLISHED.
--> KENYON 69 GIVES EVIDENCE FOR J TO BE GREATER THAN 0

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                 45  PHI (1650)   MASS (MEV)

M          1636.0     20.0            ARMENISE  68 DBC   0 5.1 PI+D        9/68
M          1670.0     20.0            KENYON    69 DBC    8 PI+ D,3PI 2P   8/69*
M          . . . . . . . . . .
M   AVG    1653.0     17.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

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                 45  PHI (1650)  WIDTH (MEV)

W          112.0      60.0            ARMENISE  68 DBC   0 5.1 PI+D        9/68
W          100.0      40.0            KENYON    69 DBC    8 PI+ D,3PI 2P   8/69*
W          . . . . . . . . . .
W   AVG    103.7      33.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 45  PHI (1650)  PARTIAL DECAY MODES

                                                              DECAY MASSES
P1          PHI (1650) INTO 3 PI                             134+ 134+ 134
P2          PHI (1650) INTO 5 PI                             134+ 134+ 134+ 134

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                 45  PHI (1650)  BRANCHING RATIOS

R1          PHI (1650) INTO (5 PI)/(3 PI)
R1             0.10      0.10         KENYON    69 DBC   0 8. PI + D       8/69*

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                              REFERENCES FOR PHI (1650)

ARMENISE 68 PL 26B 336           +GHIDINI,FORINO+ (BARI+BOLOGN+FIRENZ+ORSAY)
KENYON   69 PRL 23 146           +KINSON,SCARR,+               (BNL+ORUC+ORNL)

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$\rho_N(1660)$ "g" $\rightarrow \pi\pi$

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15  RHO (1660, JPG= N+) I=1

THIS ENTRY CONTAINS THE R1,G(2 PI) AND K KBAR PEAKS.
FOR POSSIBLE 4 PI MODES SEE RHO(1715)

CRENNELL 68 SUGGEST JP=3- FROM THE PI PI SCATTERING ANGLE DISTR.

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                 15  RHO (1660)  MASS (MEV)

M          1700.0    100.0            BELLINI   65 HLBC  0 6.1 PI-P        6/66
M         (1640.0)                    FORINO    65 DBC   0 4.5 PI+D        6/66
M          1670.0     30.0            GOLDBERG  65 HBC   0 6 PI+D, 8 PI-P
M   R     (1630.)    (15.)            DUBAL     67 MMS  -  7,11.5,12PI- P  7/67
M   R    R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
M   R    NOTE THAT THE R1 HAS MUCH SMALLER WIDTH THAN THE OTHER ENTRIES.
M         (1680.0)   (20.0)           POIRIER   67 HBC   0 8.0 PI- P      11/67
M          1683.      13.             ARMENISE  68 DBC   0 5.1 PI+ D       6/68
M          1620.      20.             BOESEBECK 68 HBC  +  8 PI+ P         6/68
M          1720.0     20.0            CRENNELL  68 HBC   0 6.0 PI- P      12/68*
M          1640.0     25.0            CRENNELL  68 HBC  -  6.0 PI- P      12/68*
M          1640.0     20.0      25.0  CRENNELL  68 HBC  +- 6.0 PI-P,KBAR K 12/68*
M          1655.0     10.0            JOHNSTON  68 HBC   0 7.0 PI- P       6/68
M       13(1650.0)                    ADERHOLZ  69 HBC  +  8 PI+ P,K+K0    8/69*
M         (1750.0)                    CASO      69 HBC   0 11. PI- P,N2PI  8/69*
M          . . . . . . . . . .
M   AVG    1663.1     10.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                         (SEE IDEOGRAM BELOW )
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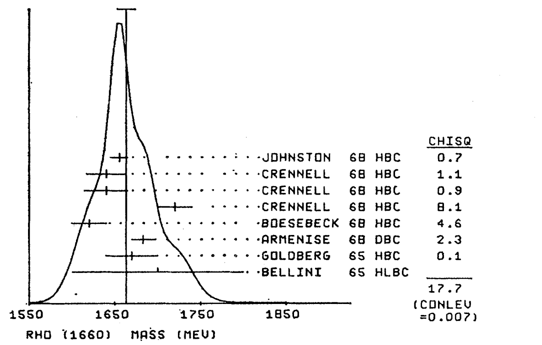
See the illustrated key preceding the data card listings.

MESON RESONANCES

Data in parentheses have not been included in our averages.

WEIGHTED AVERAGE = 1663.1 ± 10.7
ERROR SCALED BY 1.7

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                  15  RHO (1660)  WIDTH (MEV)

W           (40.0)                      FORINO    65 DBC    0 4.5 PI+D          6/66
W           180.0     40.0              GOLDBERG  65 HBC    0 6 PI+D, 8 PI-P
W   R       (21.)     OR LESS           LEVRAT    66 MMS    -  7,12 PI- P       7/67
W   R       R1 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
W          (226.0)   (68.0)   (46.0)   POIRIER   67 HBC    0 8.0 PI- P        11/67
W           188.      49.               ARMENISE  68 DBC    0 5.1 PI+ D         6/68
W           108.      40.               BOESEBECK 68 HBC   +  8 PI+ P           6/68
W           200.0    100.0              CRENNELL  68 HBC   -  6.0 PI- P        12/68*
W           200.0    100.0              CRENNELL  68 HBC    0 6.0 PI- P        12/68*
W            79.0     70.0     25.0     CRENNELL  68 HBC   +- 6.0 PI-P,KBAR K  12/68*
W            80.0     20.0              JOHNSTON  68 HBC    0 7.0 PI- P         6/68
W        13 (100.0)                     ADERHOLZ  69 HBC   +  8 PI+ P,K+K0      8/69*
W.         (200.0)                      CASO      69 HBC    0 11. PI- P,N2PI    8/69*
W           . . . . . . . . . .
W   AVG     110.9     18.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                     (SEE IDEOGRAM BELOW )
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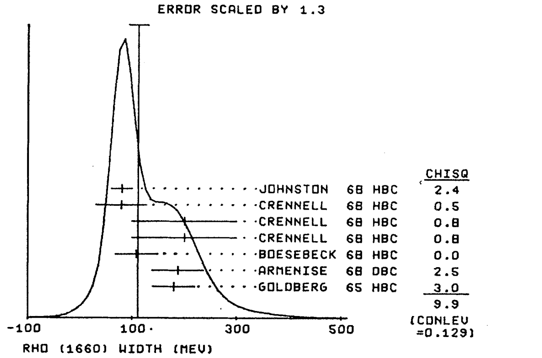
WEIGHTED AVERAGE = 110.9 ± 18.5
ERROR SCALED BY 1.3

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                15  RHO (1660)     PARTIAL DECAY MODES

                                                        DECAY MASSES
P1         RHO (1660) INTO PI PI                      139+ 139
P2         RHO (1660) INTO  4PI                       139+ 139
P5         RHO (1660) INTO K KBAR                     497+ 497

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                15  RHO (1660)  BRANCHING RATIOS
        (FOR OTHER POSSIBLE MODES SEE RHO(1715) BELOW)

R1         R1 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R1           (0.37)/   0.59 /   0.04  FOCACCI   66 MMS   -                   10/66

R3         RHO(1660) INTO (K KBAR) / (2 PI)
R3           INDICATION SEEN              EHRLICH   66 HBC  +-0 7.9 PI- P       3/67
R3           PROBABLY SEEN                ABRAMS    67 HBC    0 4.25 K- P       6/67
R3           0.08      0.08     0.03  CRENNELL  68 HBC      6.0 PI- P      12/68*

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                             REFERENCES FOR RHO(1660)

BELLINI   65 NC 40 A 948        BELLINI,DI CORATO,DUIMINO,FIORINI  (MILANO)
FORINO    65 PL 19 65           FORINO,GESSAROLI +   (BOLOGNA+ORSAY+SACLAY)
GOLDBERG  65 PL 17 354          GOLDBERG+(CERN+PARIS+ORSAY+MILANO+CEA-SACL)
EHRLICH   66 PR 152 1194        R. EHRLICH,W.SELOVE,H.YUTA   (PENNSYLVANIA)
FOCACCI   66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT    66 PL   22  714       CERN MISSING MASS SPECTROMETER GROUP (CERN)

ABRAMS    67 PRL 18 620         +KEHCE+GLASSER+SECHI-ZORN+WOLSKY (MARYLAND)
DUBAL     67 NP B3 435          CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO   68 THESIS 1456        L.DUBAL                            (GENEVE)
POIRIER   67 PR 163 1462        +BISWAS,CASON,DERADO,KENNEY+ (NOTRDAM+PENN)

ARMENISE  68 NC 54 A 999        +FORINO+CARTACCI+(BARI+BOLOG+FIRENZE+ORSAY)I
BOESEBEC  68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CRENNELL  68 PL 28 B 136        +KARSHON,LAI,SCARR,SKILLICORN         (BNL)
JOHNSTON  68 PRL 20 1414        +PRENTICE,STEENBERG,YOON      (TORONTO+WISC)

ADERHOLZ  69 NP B 11 259        +BARTSCH,+       (AACH+BERL+CERN+KRAK+WARS)
CASO      69 NC 62 A 755        +CONTE,BENZ,+    (GENO+DESY+HAMB+MILA+SACL)
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$\rho(1710)$ $\rightarrow 4\pi$

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38  RHO(1710,JPG=  +) I = 1 OR 2

THIS ENTRY CONTAINS 4PI, RHO 2PI, 2PHO, OMEGA PI,
AND K*KBAR  ENHANCEMENTS, AND THE R2.

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                  38  MASS (MEV)

M       80 1717.      7.               DANYSZ    67 HBC    OSEE NOTE R BELOW  5/67
M   R   SEEN IN 2.5-3 PBAR P. 2PI+2PI-,WITH 0,1,2 PI+PI- PAIRS IN RHO0 BAND
M   M     (1700.)    (15.)             DUBAL     67 MMS   -  7,11.5,12PI- P   7/67
M   M   R2 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
M   K     (1700.)                      FRENCH    67 HBC    0 3,3.6 PBAR P     7/67
M   K   OBSERVED IN NEUTRAL(K* KBAR) MODE  (G-PARITY UNKNOWN)
M          1720.      15.              BALTAY    68 HBC   +  7, 8.5 PI+ P     6/68
M        (1720.0)                      CASO 1    68 HBC   - 11.0PI-P,RHO 2PI  6/68
M        (1670.0)                      CASO 1    68 HBC   - 11.0 PI-P, 4PI    6/68
M   J    (1675.0)   (10.0)             JOHNSTON  68 HBC   -  7.0 PI- P        6/68
M   J      NOT SEPARATED FROM 2 PI DECAY
M          1690.0     16.0             ADERHOLZ  69 HBC   +  8 PI+ P,KKBARPI  8/69*
M          1700.0     47.0             ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69*
M          . . . . . . . . . .
M   AVG    1713.6     6.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                  38  WIDTH (MEV)

W   M      (30.)    OR LESS            LEVRAT    66 MMS   -  7-12 PI- P       7/67
W   M   R2 PEAK FROM CERN MMS EXPT. DECAY MODES AND G PARITY UNKNOWN.
W       80   40.      12.              DANYSZ    67 HBC    OSEE NOTE R BELOW  5/67
W   R   SEEN IN 2.5-3 PBAR P. 2PI+2PI-,WITH 0,1,2 PI+PI- PAIRS IN RHO0 BAND
W          100.       35.              BALTAY    68 HBC   +  7, 8.5 PI+ P     6/68
W         (120.0)                      CASO 1    68 HBC   - 11.0 PI-P, 4PI    6/68
W         (100.0)                      CASO 1    68 HBC   - 11.0PI-P,RHO 2PI  6/68
W   J      (90.0)    (20.0)            JOHNSTON  68 HBC   -  7.0 PI- P        6/68
W   J     NOT SEPARATED FROM 2 PI DECAY
W          112.0      60.0             ADERHOLZ  69 HBC   +  8 PI+ P,KKBARPI  8/69*
W         (195.0)                      ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69*
W          . . . . . . . . . .
W   AVG     48.6      18.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

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                  38  RHO (1710) PARTIAL DECAY MODES

                                                     DECAY MASSES
P1         RHO(1710) INTO 4 PI                     139+ 139+ 139+ 139
P2         RHO(1710) INTO A2 PI                    139+1300
P3         RHO(1710) INTO OMEGA PI                 139+ 783
P4         RHO(1710) INTO PHI PI                  1019+ 139
P5         RHO(1710) INTO 2 RHO                    765+ 765

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                  38  RHO(1710) BRANCHING RATIOS

R1         R2 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R1           (0.42)/   0.56 /   0.01  FOCACCI   66 MMS   -                    10/66

R2         RHO(1710)+- INTO (PI+- A20)/(ALL PI+- PI+ PI- PIO)
R2                          (WITH A20 INTO (PI+ PI- PIO))
R2           0.40      0.20           BALTAY    68 HBC   +   7,8.5 PI+P        6/68
R2           NOT SEEN                 JOHNSTON  68 HBC   -   7 PI- P           6/68

R3         RHO(1710)+- INTO (PI OMEGA)/(ALL PI+- PI+ PI- PIO)
R3                          (WITH OMEGA INTO(PI+ PI- PIO))
R3           0.25      0.10           BALTAY    68 HBC   +   7-8.5 PI+P        5/68
R3            .25      0.10           JOHNSTON  68 HBC   -   7.0 PI- P         6/68
R3           . . . . . . . . . .
R3  AVG      0.250     0.071   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R4         RHO(1710)+- INTO (PI PHI)/(ALL PI+- PI+ PI- PIO)
R4           (0.11) OR LESS           BALTAY    68 HBC   +   7,8.5 PI+P        6/68

R5         RHO(1710)+- INTO (RHO 2PI)/(ALL 4PI)
R5           CONSISTENT WITH 1.       CASO 1    68 HBC   -   11 PI- P          6/68

R6         RHO(1710)+- INTO (RHO+- RHO0)/(ALL RHO 2PI)
R6           0.48      0.16           CASO 1    68 HBC   -   11 PI- P          6/68

R7         RHO(1710)   INTO (2 RHO) / (ALL 4PI)
R7           SEEN                     DANYSZ    67 HBC    0 3-4 PBAR P         5/68
R7           SEEN                     BALTAY    68 HBC   +   7,8.5 PI+ P       6/68
R7           SEEN                     JOHNSTON  68 HBC   -   7 PI-P            6/68

R8         RHO(1710)+- INTO (PI+- 2PI+ 2PI- PIO)/(ALL PI+- PI+ PI- PIO)
R8           (0.15) OR LESS           BALTAY    68 HBC   +   7,8.5 PI+ P       6/68

R9         RHO(1710)+- INTO (PI+- PIO) / (ALL PI+- PI+ PI- PIO)
R9  D        (0.08) OR LESS           BALTAY    68 HBC   +   7-8.5 PI+ P       6/68
R9  D        USING DATA OF DEUTSCHMANN 65 ON PI+P TO PI+ PIO P                 6/68

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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.


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                        REFERENCES FOR RHO(1710)

DEUTSCHM 65 PL 18 351          M.DEUTSCHMANN ET AL    (AACHEN+BERLIN+CERN)
FOCACCI  66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL   22  714       CERN MISSING MASS SPECTROMETER GROUP (CERN)

DANYSZ   67 PL 24B 309         +FRENCH+KINSON+SIMAK+       (CERN+LIVERPOOL)
DUBAL    67 NP B3 435          +FOCACCI+KIENZLE+LECHANDINE+LEVRAT+  (CERN)
   ALSO  68 THESIS 1456        L.DUBAL                            (GENEVE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)

BALTAY   68 PRL 20 887         +KUNG+YEH+FERBEL+    (COLMB+ROCH+RUTG+YALE)I=1
CASO 1   68 NC 54 A 983        +CONTE+CORDS+DIAZ+   (GENOVA+HAMB+MIL+SACL)
JOHNSTON 68 PRL 20 1414        +PRENTICE,STEENBERG,YOON     (TORONTO+WISC)IJP

ADERHOLZ 69 NP B 11 259        +BARTSCH,+         (AACH+BERL+CERN+KRAK+WARS)
ANDERSON 69 PRL 22 1390        +COLLINS,BLIEDEN+                  (BNL+CARN)

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R(1750)

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                 39   R(1750) I=1

                 THIS ENTRY CONTAINS I=1 PEAKS AND THE R3 PEAK
                 NOT A FIRMLY ESTABLISHED RESONANCE - OMITTED FROM TABLE
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                 39   R(1750) MASS(MEV)

M         1748.     16.          DUBAL     67 MMS   -  7,11.5,12 PI- P  7/67
M   F    (1740.)                 FRENCH    67 HBC  (KO K+-) 3-4 PBAR P  7/67
M   F     SEE FIG. 9 OF FRENCH 67

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                 39   R(1750) WIDTH (MEV)

W          (38.)   OR LESS       LEVRAT    66 MMS   -  7,12 PI- P       7/67
W   F     (120.)   APPROX.       FRENCH    67 HBC  (KO K+-) 3-4 PBAR P 11/69*
W   F      ABOVE VALUE ESTIMATED FROM FIG. 9 OF FRENCH 67

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                 39  R(1750) BRANCHING RATIOS

R3        R3 MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R3  C       (0.14)/   0.80 /   0.05  FOCACCI   66 MMS   -              10/66
R3  C        FRACTION INTO ONE CHARGED  PROB. LARGER THAN GIVEN ABOVE.
R3  C                                                   CF. DUBAL 67

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                        REFERENCES FOR R (1750)

FOCACCI  66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
LEVRAT   66 PL   22  714       CERN MISSING MASS SPECTROMETER GROUP (CERN)
DUBAL    67 NP B3 435          CERN MISSING MASS SPECTROMETER GROUP (CERN)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)

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$\eta_{A,I\geq 0}(1830) \to 4\pi, K^*\bar{K}$

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                        42 ETA OR RHO (1830)  G=+1 (JPG=  +)
                           I=0 OR GREATER
                 THIS ENTRY CONTAINS 4 PI AND K PI KBAR AND THE
                 R4 MMS PEAK. R4 IS ONLY A 3 STANDARD DEVIATIONS EFFECT.
                 OMITTED FROM TABLE.
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                 42 MASS (MEV)

M      110 1832.      6.         DANYSZ    67 HBC    OSEE NOTE R BELOW  5/67
M   R        SEEN IN 2.5-3. PBAR P. 2PI+2PI-, WITH 0,1,2 PI+PI- PAIRS
M   R                                                IN RHOO BAND
M   M     (1830.)    (15.)       DUBAL     67 MMS   -  7,11.5,12.PI- P  6/68
M   M        MISSING MASS R4 PEAK,FINAL STATE UNKNOWN
M            1820.    12.        FRENCH    67 HBC    OSEE NOTE K BELOW  7/67
M   K        SEEN IN 3.-3.6 PBAR P TO (KS KO PIO...). G PARITY UNKNOWN
M            . . . . . . . . .
M   AVG      1829.6    5.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 42 WIDTH (MEV)

W      110    42.     11.        DANYSZ    67 HBC    OSEE NOTE R BELOW  5/67
W   R         SEEN IN 2.5-3. PBAR P. 2PI+2PI-, WITH 0,1,2 PI+PI- PAIRS
W   R                                                IN RHOO BAND
W   M       (30.0) OR LESS       DUBAL     67 MMS   - 7,11.5,12 PI-P    6/68
W   M         MISSING MASS R4 PEAK,FINAL STATE UNKNOWN
W             50.     23.        FRENCH    67 HBC    OSEE NOTE K BELOW  7/67
W   K         SEEN IN 3.-3.6 PBAR P TO (KS KO PIO...). G PARITY UNKNOWN
W            . . . . . . . . .
W   AVG       43.5     9.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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                 42 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          ETA OR RHO (1830) INTO 4 PI                139+ 139+ 139+ 139
P2          ETA OR RHO (1830) INTO RHO PI PI           139+ 139+ 765
P3          ETA OR RHO (1830) INTO RHO RHO             765+ 765
P4          ETA OR RHO (1830) INTO K KBAR PI           134+ 497+ 497

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                          REFERENCES

DANYSZ   67 PL 24B 309         +FRENCH+KINSON+SIMAK+       (CERN+LIVERPOOL)
DUBAL    67 NP B3 435          CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456        L.DUBAL                            (GENEVE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)

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$\phi_{A,I\geq 0}(1830) \to 5\pi, K^*\bar{K}$

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                 43 PHI OR PI (1830)  G=-1 (JPG=  -) I=0 OR GREATER
                 THIS ENTRY CONTAINS OMEGA PI PI AND K PI KBAR AND
                 THE R4 PEAK. R4 IS ONLY A 3 STANDARD DEVIATIONS EFFECT.
                 I=1 IF (OMEGA RHO) MODE EXISTS.
                 OMITTED FROM TABLE.
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                 43  MASS (MEV)

M   O    (1848.)    (11.)        DANYSZ    67 HBC    0 3,3.6 PBAR P     7/67
M   O     OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
M   K    (1820.)    (12.)        FRENCH    67 HBC    0 3,3.6 PBAR P     7/67
M   K     OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)
M   M    (1830.)    (15.)        DUBAL     67 MMS   -  7,11.5,12.PI- P  6/68
M   M     MISSING MASS R4 PEAK,FINAL STATE UNKNOWN

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                 43  WIDTH (MEV)

W   O      (67.)    (27.)        DANYSZ    67 HBC    0 3,3.6 PBAR P     7/67
W   O       OBSERVED IN (OMEGA PI+ PI-) (AND POSSIBLY (OMEGA RHO(0))) MODE
W   K      (50.)    (20.)        FRENCH    67 HBC    0 3-4 PBAR P       7/67
W   K       OBSERVED IN (KS KO PIO...) MODE  (G-PARITY UNKNOWN)
W   M      (30.0) OR LESS        DUBAL     67 MMS   - 7,11.5,12 PI-P    6/68
W   M       MISSING MASS R4 PEAK,FINAL STATE UNKNOWN

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                 43 PARTIAL DECAY MODES

                                                          DECAY MASSES
P1          PHI (1830) INTO 5 PI                       139+ 139+ 139+ 139
P2          PHI (1830) INTO OMEGA PI PI                139+ 139+ 783
P3          PHI (1830) INTO OMEGA RHO                  783+ 765
P4          PHI (1830) INTO K KBAR PI                  134+ 497+ 497

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                          REFERENCES

DANYSZ   67 NC 51A 801         DANYSZ+FRENCH+SIMAK                  (CERN)
DUBAL    67 NP B3 435          CERN MISSING MASS SPECTROMETER GROUP (CERN)
   ALSO  68 THESIS 1456        L.DUBAL                            (GENEVE)
FRENCH   67 NC 52A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)

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S(1930) REGION

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                 31 S(1930,JPG=   ) I=1 CR 2

                 THIS ENTRY CONTAINS, BESIDES THE S(1930) SEEN BY
                 CHIKOVANI 66 WITH A MMS, VARICUS OTHER PEAKS NEARBY.
                 SEE MONTANET 69 FOR A REVIEW OF STATUS.
                 OMITTED FROM TABLE.
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                 31  S (1930)  MASS (MEV)

M         1929.0    14.0         CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
M         1900.     40.          BOESEBECK 68 HBC  +  8 PI+ P,PI+ PIO   6/68
M   C    (1985.0)                CASO      68 HBC  - 11.0 PI- P         9/68
M   C     SEEN IN RHO- PI+ PI- (OMEGA ANTISELECTED)
M        (1945.0)                CLINE     68 HBC     .3-.7 PB P ELAST  9/68
M        (1925.0)                CLINE     68 HBC     .3-.7 PB P ELAST  9/68
M         . . . . . . . . . .
M   AVG   1925.8    13.2     AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.0)

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                 31  S (1930) WIDTH (MEV)

W         (35.0)  OR LESS        CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
W          216.    105.          BOESEBECK 68 HBC  +  8 PI+ P,PI+ PIO   6/68
W   C    (100.0)                 CASO      68 HBC  - 11.0 PI- P         9/68
W   C     SEEN IN RHO- PI+ PI- (OMEGA ANTISELECTED)
W         (22.0)                 CLINE     68 HBC     .3-.7 PB P ELAST  9/68
W         (10.0)                 CLINE     68 HBC     .3-.7 PB P ELAST  9/68

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                 31 D(SIGMA)/D(T) ( MICRCBARNS/(GEV/C)**2 )

CS          35.0    12.0         FOCACCI   66 MMS  .22 LTE T LTE .36    9/66

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                        REFERENCES FOR S(1930)

CHIKOVAN 66 PL  22  233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
BOESEBEC 68 NP B 4 501         BOESEBECK,DEUTSCHMANN,+(AACHEN+BERLIN+CERN)
CASO     68  VIENNA CONF. 325 +CONTE,CORDS,RATTI+ (GENOA+HAMB+MILAN+SACL)
CLINE    68 PRL 21 1268        +ENGLISH,REEDER,TERRELL,TWITTY  (WISCONSIN)
MONTANET 69 LUND CONF. REVIEW L.MCNTANET

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$\rho(\sim 2100)$ REGION

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                 51  RHO (2100, JPG=  +) I=1

                 NICHOLSON 69 SUGGEST IG=1+,JP=3- FROM  ANALYSIS OF
                 DIFFERENTIAL CROSS-SECTIONS.
                 OMITTED FROM TABLE.
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                 51  RHC (2100)  MASS (MEV)

M         2086.0    38.0         ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69*
M        (2120.)                 NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI  9/69*

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                 51  RHO (2100)  WIDTH (MEV)

W        (150.0)                 ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69*
W   N    (249.)                  NICHOLSON 69 CNTR   0 .7-2.4 PB P,2PI  9/69*
W   N     THE WIDTH INCLUDES RESOLUTION.

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                        REFERENCES FOR RHO(2100)

ANDERSON 69 PRL 22 1390        +COLLINS,BLIEDEN+                  (BNL+CARN)
NICHOLSO 69 PRL 23 603         NICHOLSON,BARISH,DELORME,+  (CALT+ROCH+BNL)

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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

T(2200) REGION

```
32 T(2200,JPG=   ) I=1 OR 2

THIS ENTRY CONTAINS, BESIDES THE T(2200) SEEN BY
CHIKOVANI 66 WITH A MMS, VARIOUS OTHER PEAKS NEARBY.
SEE MONTANET 69 FOR A REVIEW OF STATUS.
OMITTED FROM TABLE.
------ --------- --------- --------- --------- --------- --------- --------

                32 T(2200)  MASS (MEV)

M          2195.0     15.0              CHIKOVANI 66 MMSP  -  12.0 PI-P          8/66
M   B     (2190.)     (5.)              ABRAMS    67 CNTR    S CHANNEL NBAR N   7/67
M   B      SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN
M   B      THE MMSP EXPT.  SEE ALSO COOPER 68
M   B      BRICMAN (69) SEES NO BUMP, SPIN LESS THAN 5 IS SO EXCLUDED
M          2207.      13.               ALLES-BOR 67 HBC    0 5.7 PBAR P        12/66
M   A      ALLES-BORELLI 67 SEE NEUTRAL MODE ONLY (PI+PI-PIO)
M          2190.0     10.0              CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA  10/67
M   C     (2200.0)                      CASO      68 HBC   - 11.0 PI- P          9/68
M   C      SEEN IN RHO- PI+ PI- (OMEGA ANTISELECTED)
M   K     (2190.0)                      KALBFLEIS 69 HBC    0 S-CHANNEL PBARP   7/69*
M   K      SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.
M   O     (2176.)     (5.)              BAUBILLI  69 HBC    0 S-CHANNEL PBARP  11/69*
M   O      SEEN IN PBAR P TO K1 K1 OMEGA
M          . . . . . . . . . .
M   AVG    2196.0      7.0    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

------ --------- --------- --------- --------- --------- --------- --------

                32 T(2200) WIDTH (MEV)

W           (13.0)  OR LESS             CHIKOVANI 66 MMSP  -  12.0 PI-P          8/66
W   B       (85.)                       ABRAMS    67 CNTR    S CHANNEL NBAR N   7/67
W   B        SEE NOTE B UNDER T(2200) MASS ABOVE.
W            62.      52.               ALLES-BOR 67 HBC    0 5.7 PBAR P        12/66
W   C      (130.0)                      CASO      68 HBC   - 11.0 PI- P          9/68
W   C        SEEN IN RHO- PI+ PI- (OMEGA ANTISELECTED)
W   K      BETWEEN 20 AND 80 MEV        KALBFLEIS 69 HBC    0 S-CHANNEL PBARP   7/69*
W   K      . SEEN IN PBAR P TO RHOO RHOO PIO. IG=1-.
W   O       (20.)    (16.)     (2.)     BAUBILLI  69 HBC    0 S-CHANNEL PBARP  11/69*
W   O        SEEN IN PBAR P TO K1 K1 OMEGA

------ --------- --------- --------- --------- --------- --------- --------

                32 D(SIGMA)/D(T) ( MICROBARNS/(GEV/C)**2 )

CS           29.0     10.0              FOCACCI   66 MMS  .22 LTE T LTE .36    9/66

------ --------- --------- --------- --------- --------- --------- --------

                32 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS           (6.)                       ABRAMS    67 CNTR    S CHANNEL NBAR N   7/67
CS  K        (0.5)    (0.1)             KALBFLEIS 69 HBC    0                   7/69*
CS  K         PBAR P TO RHOO RHOO PIO                                           7/69*

****** ********* ********* ********* ********* ********* ********* ********

                      REFERENCES FOR T(2200)
```


```
CHIKOVAN 66 PL  22  233        CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890       CERN MISSING MASS SPECTROMETER GROUP (CERN)
ABRAMS   67 PRL 18 1209        +COOL+GIACOMELLI+KYCIA+LEONTIC+LI+     (BNL)
ALLES-BO 67 NC 50 A 776        ALLES-BORELLI,FRENCH,FRISK,+     (CERN+BONN)G=-
CASO     68  VIENNA CONF. 325 +CONTE,CORDS,RATTI+ (GENOA+HAMB+MILAN+SACL)
CLAYTCN  67 HEIDBG.CONF.P.57   +MASON,MUIRHEAD,FILIPPAS+  (LIVPOOL+ATHENS)
COOPER   68 PRL 20 1059        +HYMAN,MANNER,MUSGRAVE,VOYVODIC        (ANL)

BAUBILLI 69 LUND PAPER 87      BAUBILLIER,DUBOC,HURIAUX,GIBBINS,+(IPN+LIV)
BRICMAN  69 PL 29 B 451        +RERRO-LUZZI,BIZARD,+       (CERN+CAEN+SACL)
CASO     69 NC 62 A 755        +CONTE,BENZ,+     (GENO+DESY+HAMB+MILA+SACL)
KALBFLEI 69 PL 29 B  259       G.KALBFLEISCH,R.STRAND,V.VANDERBURG    (BNL)
MONTANET 69 LUND CONF. REVIEW L.MONTANET
```


```
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

ρ(~2275) REGION

```
52  RHO (2275, JPG=  +) I=1

NICHOLSON 69 SUGGEST IG=1+,JP=5- FROM  ANALYSIS OF
DIFFERENTIAL CROSS-SECTIONS.
OMITTED FROM TABLE.
------ --------- --------- --------- --------- --------- --------- --------

                52  RHO (2275)  MASS (MEV)

M          2260.0     18.0              ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69*
M         (2290.)                       NICHOLSON 69 CNTR  0 .7-2.4 PB P,2PI   9/69*

------ --------- --------- --------- --------- --------- --------- --------

                52  RHO (2275)  WIDTH (MEV)

W           (25.0) OR LESS              ANDERSON  69 MMS   -  16 PI- P,BACKW   8/69*
W   N      (165.)                       NICHOLSON 69 CNTR  0 .7-2.4 PB P,2PI   9/69*
W   N       THE WIDTH INCLUDES RESOLUTION.

****** ********* ********* ********* ********* ********* ********* ********

                      REFERENCES FOR RHO(2275)
```


```
ANDERSON 69 PRL 22 1390        +COLLINS,BLIEDEN+                (BNL+CARN)
NICHOLSO 69 PRL 23 603         NICHOLSON,BARISH,DELORME,+  (CALT+ROCH+BNL)
```


```
****** ********* ********* ********* ********* ********* ********* ********
****** ********* ********* ********* ********* ********* ********* ********
```

U(2375) REGION

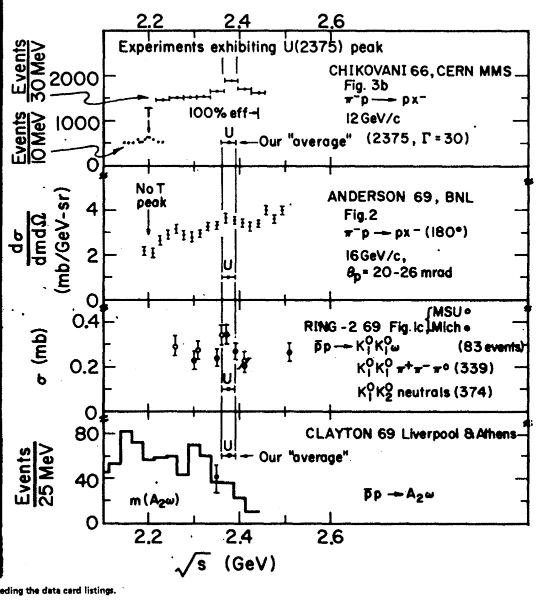
```
33 U(2375,JPG=   ) I=1 OR 2
```

<u>Note on U(2375)</u>

The CERN Missing-Mass Spectrometer group have reported narrow peaks above 1700 MeV called R, S, T, U, and X^-. All except U(2380) are still omitted from the Meson Table because the supporting evidence is either insufficient or, in the R, S, and T regions, suggests more than one resonance. See the Lund Conference Report of MONTANET 69.

However, the evidence supporting the original, narrow ($\Gamma \lesssim 30$ MeV) U(2380) seems sufficiently consistent so that we have included it in the table. This evidence is presented in the figure below. There is also a bump in the I = 1 σ ($\bar{p}p$) reported by ABRAMS 67, but it is 140 MeV wide and is not drawn.

We thank the University of Michigan and Michigan State University HBC groups for informing us to their combined events ($\bar{p}p \rightarrow K_1K_1\omega$, $K_1K_1\pi^+\pi^-\pi^0$, K_1K_π+neutrals).



Data in parentheses have not been included in our averages.

```
                    33 U(2375)  MASS (MEV)

M          2382.0     24.0            CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
M    B    (2345.)    (10.)            ABRAMS    67 CNTR    S CHANNEL NBAR N  7/67
M    B     SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN MMS EXPT.
M         (2380.0)   (10.0)           CLAYTON   67 HBC  +- 2.5PBAR,A2+OMEGA 11/69*
M          2370.      17.             ANDERSON  69 ASPK  - 16 PI- BKSCAT    11/69*
M          2370.0     10.0            RING2     69 HBC    0 S-CHANNEL PBARP 11/69*
M          . . . . . . . . . .
M    AVG   2371.4     8.1      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

                    33 U(2375) WIDTH (MEV)

W           (30.0)  OR LESS           CHIKOVANI 66 MMSP  -  12.0 PI-P        8/66
W    B     (140.)                     ABRAMS    67 CNTR    S CHANNEL PBAR N  7/67
W    B     SEEN AS BUMP IN I=1 STATE. WIDTH MUCH LARGER THAN IN MMS EXPT.
W           (57.)                     ANDERSON  69 ASPK  - 16 PI- BKSCAT    11/69*
W           (40.0)  OR LESS           RING2     69 HBC    0 S-CHANNEL PBARP 11/69*

                    33 D(SIGMA)/D(T) ( MICROBARNS/(GEV/C)**2 )

CS            42.0     14.0    .      FOCACCI   66 MMS  .28 LTE T LTE .36    9/66

                    33 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS            (3.)                    ABRAMS    67 CNTR    S CHANNEL NBAR N  7/67

                    33  U MESON BRANCHING RATIOS

R1         U- MESON FRACTION INTO ONE / THREE / FIVE OR MORE CHARGED TRACKS
R1           (0.30)/   0.45 /   0.25  FOCACCI   66 MMS   -                  10/66

                               REFERENCES FOR U(2375)
```


```
CHIKOVAN 66 PL  22  233       CERN MISSING MASS SPECTROMETER GROUP (CERN)
FOCACCI  66 PRL  17  890      CERN MISSING MASS SPECTROMETER GROUP (CERN)
ABRAMS   67 PRL 18 1209       +COOL+GIACOMELLI+KYCIA+LEONTIC+LI+     (BNL)
CLAYTCN  67 HEIDBG.CONF.P.57  +MASON,MUIRHEAD,FILIPPAS+  (LIVPOOL+ATHENS)
ANDERSON 69 PRL  22 1390      +BLESER,BIRNBAUM,EDELSTEIN,+     (BNL+CARN)
BRICMAN  69 PL 29 B 451       +FERRO-LUZZI,BIZARD,+       (CERN+CAEN+SACL)
CASO     69 NC 62 A 755       +CONTE,BENZ,+     (GENO+DESY+HAMB+MILA+SACL)
MA       69 BOULDER CONF PREP +OH,PARKER,SMITH,SPRAFKA              (MICH)
MCNTANET 69 LUND CONF REVIEW  L. MONTANET
RING1    69 MICH PREPRINT     +CHAPMAN,CHURCH,LYS,MURPHY,VANDERVELD(ANNA)
RING2    69 MICH PREPRINT     +CHAPMAN,CHURCH,OH,PARKER,SMITH+(ANNA+MICH)
```


$N\bar{N}_{I=0}(2380)$

```
41 N NBAR (2380) (I=0)

EVIDENCE FOR RESONANCE PRELIMINARY,
OMITTED FROM TABLE.

                    41 MASS

M           2380.     10.             ABRAMS    67 CNTR    S CHANNEL NBAR N  7/67

                    41 WIDTH
W           (140.)                    ABRAMS    67 CNTR    S CHANNEL NBAR N  7/67

                    41 SIGMA (MB) FOR FORMATION BY NUCLEON ANTINUCLEON

CS            (2.)                    ABRAMS    67 CNTR                      7/67

                               REFERENCES FOR N NBAR (2380)
```


```
ABRAMS   67 PRL 18 1209       +COOL+GIACOMELLI+KYCIA+LEONTIC+LI+     (BNL)
BRICMAN  69 PL 29 B 451       +RERRO-LUZZI,BIZARD,+     (CERN+CAEN+SACL)
```


$X^-(2500)$

```
46    X- (2500, JPG=    ) I=1 OR 2

      OMITTED FROM TABLE

                    46  X- (2500)  MASS (MEV)

M          2500.0     32.0            ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69*

                    46  X- (2500)  WIDTH (MEV)

W           (87.0)                    ANDERSON  69 MMS   -  16 PI- P,BACKW9  8/69*

                               REFERENCES FOR X-(2500)
```


```
ANDERSCN 69 PRL 22 1390       +COLLINS,+                        (BNL+CARN)
```


$X^-(2620)$

```
48    X- (2620, JPG=    ) I=1 OR 2

      OMITTED FROM TABLE

                    48  X- (2620)  MASS (MEV)

M      550 2620.      20.             BAUD      69 MMS   -  8.-10. PI- P     9/69*

                    48  X- (2620)  WIDTH (MEV)

W      550   85.      30.             BAUD      69 MMS   -  8.-10. PI- P     9/69*

                               REFERENCES FOR X-(2620)
```


```
BAUD     69 PL  308 129       +BENZ,BOSNJAKOVIC,BOTTERILL,KIENZLE,+(CERN)
```


$X^-(2800)$

```
49    X- (2800, JPG=    ) I=1 OR 2

      OMITTED FROM TABLE

                    49  X- (2800)  MASS (MEV)

M      64C 2800.      20.             BAUD      69 MMS   -  8.-10. PI- P     9/69*

                    49  X- (2800)  WIDTH (MEV)

W      640   46.      10.             BAUD      69 MMS   -  8.-10. PI- P     9/69*

                               REFERENCES FOR X-(2800)
```


```
BAUD     69 PL  308 129       +BENZ,BOSNJAKOVIC,BOTTERILL,KIENZLE,+(CERN)
```


$X^-(2880)$

```
50    X- (2880, JPG=    ) I=1 OR 2

      OMITTED FROM TABLE

                    50  X- (2880)  MASS (MEV)

M      230 2880.      20.             BAUD      69 MMS   -  8.-10. PI- P     9/69*

                    50  X- (2880)  WIDTH (MEV)

W      230            15.  OR LESS    BAUD      69 MMS   -  8.-10. PI- P     9/69*

                               REFERENCES FOR X-(2880)
```


```
BAUD     69 PL  308 129       +BENZ,BOSNJAKOVIC,BOTTERILL,KIENZLE,+(CERN)
```


K

```
K MESON          ( JP=0- )   I=1/2

SEE LISTINGS OF STABLE PARTICLES
```

$\kappa(725)$

```
17  KAPPA (725,JP=  )  I=1/2

EVIDENCE NOT COMPELLING. OMITTED FROM TABLE.
FOR A COMPILATION, SEE APPENDIX A OF JAN 67 EDITION
(RMP 39, 1) OF THIS DATA SUMMARY.
SEE ALSO ROSENFELD, PROC.1968 UNIV.OF PENN.CONF.ON MESON SPECTROSCOPY
```

$K^*(892)$

```
18  K*  (892,JP =1- )  I=1/2

                    18  K* (892) MASS (MEV)

M  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
M           898.0      5.0            CHADWICK  63 HBC  +   1.5 K+P
M           891.0      3.0            FERRO-LUZ 65 HBC  +   3.0 K+P
M           895.       3.             BOMSE     67 HBC  +  2.3 K+P                7/67
M           891.       2.             DE BAERE  67 HBC  +  3.5 K+P (KO PI+)       7/67
M           892.5      2.5            DE BAERE  67 HBC  +  3.5 K+P (K+ PIO)       7/67
M           898.       4.             SALLSTROM 67 HBC  +  3. K+ P (KO PI+)       7/67
M           883.       5.             SALLSTRCM 67 HBC  +  3. K+ P (K+ PIO)       7/67
M           890.       2.             BARLOW    67 HBC  +-  1.2 PBAR P           11/66
M           889.       3.             BARLOW    67 HBC  +-  1.2 PBAR P           11/66
M           896.0      5.0            CONFORTO  67 HBC  +-  0. PBAR P             9/67
M      3870 891.0      1.0            WOJCICKI1 64 HBC  -   1.7 K-P
M           889.5      2.5            ADELMAN   65 HBC  -   1.5 K-P               6/66
M           895.0      3.0            GELSEMA   65 HBC  -   1.5 K-P
M           893.       4.             ADERHOLZ  68 HBC  -   10 K- P               6/68
M           891.       4.             FICENEC1  68 HBC  -   1.3 K-P (K-PIO)       9/67
M           887.       3.             FICENEC1  68 HBC  -   1.3 K-P (KOPI-)       9/67
M           890.0      5.0            FICENEC2  68 HBC  -   2.7 K- P(K-PIO)       2/69*
M           892.0      3.0            FICENEC2  68 HBC  -   2.7 K- P(KOPI-)       2/69*
M           896.0      4.0            SCHWEINGR 68 HBC  -   4.1 K-P               9/67
M           892.0      2.0            SCHWEINGR 68 HBC  -   5.5 K-P               9/67
M           884.0      5.0            KANG      68 HBC  -   4.6 K- P              7/69*
M           891.0      2.0            CRENNELL  69 DBC  -   3.9 K-N (KOPI-)       7/69*
M           892.0      3.0            ERWIN     69 HBC  +   3.5 K+ P              9/69*
M      2886 894.       1.             FRIEDMAN  69 HBC  -   2.1  K-P (3BDY)       9/69*
M       728 892.       2.             FRIEDMAN  69 HBC  -   2.45 K-P (3BDY)       9/69*
M      3229 892.       1.             FRIEDMAN  69 HBC  -   2.6  K-P (3BDY)       9/69*
M      1027 892.       1.             FRIEDMAN  69 HBC  -   2.7  K-P (3BDY)       9/69*
M           895.       2.             LIND      69 HBC  +   9. K+ P               9/69*
M           . . . . . . . . .
M    AVG    892.05     0.38     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
```

See the illustrated key preceding the data card listings.

The K^* Masses and Mass Difference

This note is divided into three discussions:

I. Basic difficulties in determining the mass difference because of interferences and biases.

II. Several experiments report impossibly small errors. We have increased some errors that violate the laws of statistics, and scaled up some errors that are inconsistent; but we warn that most of the errors in our data cards are inconsistent. One cannot then obtain a K^* mass difference by calculating an average mass for K^{*0} and for $K^{*\pm}$ and just subtracting the two.

III. We summarize the two experiments that explicitly report a mass difference.

I. BASIC DIFFICULTIES

There are two difficulties in measuring a mass difference $m(K^{*0}) - m(K^{*\pm})$ of ~ 7 MeV when the half-width $\Gamma/2$ of the K^* is 25 MeV:

1) Interference between the resonant amplitude and background can in general shift the peak in the mass spectrum by some fraction of $\Gamma/2$.

2) The two charges of K^* have different topologies; this introduces differences in the measuring and fitting of the events, which can also produce mass shifts.

Some reactions (symmetric under reflection of I_z) are immune to the first difficulty. Thus compare the mass of K^{*0} produced in

$$\pi^- p \to \Lambda \pi^- K^+$$

with the mass of K^{*+} in the I_z-reflected reaction

$$\pi^+ n \to \Lambda \pi^+ K^0 .$$

The final-state amplitudes of each will contain not only the $|K^*\rangle$ with Ispin 1/2, but also an interfering $I = 3/2$ P-wave, which we can call $|K^*_{3/2}\rangle$. But I_z symmetry forces $\langle \pi^- p | \Lambda K^{*0}\rangle$ to equal $\langle \pi^+ n | \Lambda K^{*+}\rangle$; and similarly for the two $K^*_{3/2}$ amplitudes, so that the shifting of the K^* peak is the same in both reactions. Nobody has published a mass difference exploiting this fact.

Two groups have reported K^* mass splittings. BARASH 67 report $m^0 - m^{\pm} = 6.3 \pm 4.1$ MeV. FICENEC 68 report 10 ± 4, but we have had to change some of their errors. This leads us to the following digression.

II. IMPOSSIBLY SMALL ERRORS

Consider a sample of N events, with their invariant masses m distributed as an S-wave Breit-Wigner resonance:

$$\text{i.e.,} \qquad P(\epsilon - \epsilon_R) = \frac{1/\pi}{(\epsilon - \epsilon_R)^2 + 1} , \tag{1}$$

where $\epsilon = \frac{m}{\Gamma/2}$, $\epsilon_R = \frac{m_R}{\Gamma/2}$. One can then show that the minimum possible error on the determination of the central value ϵ_R is

$$\delta_{min}(\epsilon_R) = \pm\sqrt{\frac{2}{N}} , \text{ i.e., } \delta_{min}(m_R) = \pm\sqrt{\frac{2}{N}}\,\frac{\Gamma}{2} . \tag{2}$$

This lower limit assumes no background events. In practice, with background, the error will be larger, by another factor $\alpha \approx \sqrt{2}$.

We illustrate errors with small and large backgrounds with a table summarizing the recent experiment ("Unsplit K^*'s") by DAVIS 69.

Mass Errors δm of DAVIS 69

- Sample with 5% background/signal at peak.

Events: $K^*(892)$, 10 700 events in resonance, $\frac{\Gamma}{2} \approx 25$ MeV.

Lower limit from Eq. (2), $\delta_{min}(m) = \sqrt{\frac{2}{N}}\ \frac{\Gamma}{2} = \pm 0.35$ MeV.

Their likelihood fit yields two sorts of errors:

$\delta_1(m)$. Ignore correlations, i.e., keep all the parameters (background, width, etc.) fixed, vary m only:

$\delta_1(m) = \pm 0.41$, $\delta_1(m)/\delta_{min}(m) = 1.16$.

$\delta_2(m)$. As m is varied, reoptimize other parameters.

$\delta_2(m) = \pm 0.53$, $\delta_2(m)/\delta_{min}(m) = 1.5$.

DAVIS 69 mention $\delta_2 = 0.53$, but to hedge against systematic effects, they quote $\delta_3 = 2$ MeV. We punch 2 MeV.

- Sample with 50% background/signal at peak.

Events: $K^*(1420)$, 2200 events in resonance, $\frac{\Gamma}{2} = 50$ MeV.

$\delta_{min}(m) = 1.6$ MeV,

$\delta_1(m) = \pm 2.2$ MeV, $\delta_1(m)/\delta_{min}(m) = 1.4$,

$\delta_2(m) = \pm 2.6$ MeV, $\delta_2(m)/\delta_{min}(m) = 1.6$.

Width Errors $\delta\Gamma$ of DAVIS 69

For width, the equivalent of Eq. (2) is $\delta_{min}(\Gamma) = \pm\sqrt{\frac{8/3}{N}}\ \frac{\Gamma}{2} = 1.15\,\delta_{min}(m)$.

For convenience we neglect the factor 1.15 and use $\delta_{min}(\Gamma) \approx \delta_{min}(m)$.

- 5% background, $K^*(892)$:

$\delta_2(\Gamma) = \pm 1.6$ MeV, $\delta_2(\Gamma)/\delta_{min}(m) = \frac{1.6}{0.35} = 4.6$.

- 50% background, $K^*(1420)$:

$\delta_2(\Gamma) = \pm 10$ MeV, $\delta_2(\Gamma)/\delta_{min}(m) = \frac{10}{1.6} = 6.25$.

We note that $\delta_2(m)/\delta_{min}(m)$ does not change rapidly with background (1.5 at 5%, 1.6 at 50%) and hence conclude that it is hard to believe an error with $\delta_2/\delta_{min} < 1.4 = \sqrt{2}$. We chose $\sqrt{2}$ because together with Eq. (2) it leads to the simple "realistic" result

$$\delta(m) > \sqrt{2}\sqrt{\frac{2}{N}}\ \frac{\Gamma}{2} = \frac{\Gamma}{\sqrt{N}}\,. \qquad (3)$$

Now contrast the error of DE BAERE 69. They were mainly interested in other questions ($d\sigma/dt$, etc.) but quote $m(K^*) = 890 \pm 0.5$ MeV. They have only 2000 events above background, and Eq. (2) yields $\delta_{min} = \sqrt{\frac{2}{2000}} \times 25$ MeV $= \pm 0.8$ MeV. The "realistic" Eq. (3) yields ± 1.1 MeV. Actually, taking into account their background/signal of 4300/2000, we have encoded ± 1.25 MeV.

Notice the absurd inconsistencies in the errors on the data cards for DE BAERE 69 and DAVIS 69. We have raised the former from 0.5 to 1.25, but have no way to estimate their systematic errors. The latter experiment has 5 times as many events, and 15 times better signal-to-noise, yet DAVIS 69 are conservative, and report ± 2 MeV, which we have encoded.

We conclude that for a sensitive subtraction like $m(K^{*0}) - m(K^{*\pm})$, the experiments as listed are useless, and we must either re-evaluate them all or concentrate on those two experiments that explicitly quote a mass difference. When we examine even these two experiments we still find one impossibly small error. We have not had the manpower to work on the longer list.

The table above also allows us to concoct a criterion for "realistic" errors in width, $\delta(\Gamma)$. We average the 5% and 50% background results (to give $\delta(\Gamma)/\delta_{min}(m)$ of 5 to 6) and express the result in terms of Γ, in the style of Eq. (3). We then get the "realistic" test for widths:

$$\delta\Gamma > 4 \frac{\Gamma}{\sqrt{N}} \tag{4}$$

III. EXPERIMENTS THAT REPORT MASS DIFFERENCES

These two experiments are summarized in the following table:

- BARASH 67: Stopping $\bar{p}p \rightarrow K_1^0 K^{\pm}\pi^{\mp}$

  $\frac{\Gamma}{2}$(resol) = 10 MeV, i.e., < $\frac{\Gamma}{2}(K^*)$ = 25 MeV.

Results for:	Events in peak Region: Above bkgd. N_A	Bkgd. N_B	$\pm\frac{\Gamma}{\sqrt{N_A}}$ · From Eq. (3).
(1) $K_1 K^{*0}$	200	70	±3.5
(2) $K^{\pm} K^{*\mp}$	130	140	±4.4

They quote $m^0 - m^- = 6.3 \pm 4.1$; we use 6.3 ± 6 MeV.

- FICENEC-1 68: 1.33 GeV/c $K^-p \rightarrow$ 3 bodies

  $\frac{\Gamma}{2}$ (resolution) = 25 MeV, i.e., = $\frac{\Gamma}{2}(K^*)$.

Results for:	Events in peak Region: Above bkgd. N_A	Bkgd. N_B	Mass published (MeV)	$\pm\frac{\Gamma}{\sqrt{N_A}}$	Mass used (MeV)	Average (MeV)
(1) nK^{*0} in $nK^-\pi^+$	700	130	895 ± 2	±1.9	895 ± 4	895.0 ± 4 {See comments below
(2) pK^{*-} in $pK^-\pi^0$	340	170	891 ± 4	±2.7	891 ± 4	888.5 ± 2.4
(3) pK^{*-} in $pK_1^0\pi^-$	330	140	887 ± 3	±2.7	887 ± 3	
	1370				$m^0 - m^-$ =	6.5 ± 5

- FICENEC-2 68: 2.7 GeV/c $K^-p \rightarrow$ same reactions

  Resolution same as FICENEC-1 68:

Results for:	Events in peak Region: Above bkgd. N_A	Bkgd. N_B	Mass published (MeV)	$\pm\frac{\Gamma}{\sqrt{N_A}}$	Mass used (MeV)	Average (MeV)
(1) nK^{*0} in $nK^-\pi^+$	730	290	901 ± 1	±1.9	901 ± 4	901.0 ± 4 {See comments below
(2) pK^{*-} in $pK^-\pi^0$	360	270	890 ± 5	±2.6	890 ± 5	891.5 ± 2.6
(3) pK^{*-} in $pK_1^0\pi^-$	480	160	892 ± 3	±2.3	892 ± 3	
	1570				$m^0 - m^-$ =	9.5 ± 5

Comments on BARASH 67: The quoted errors are slightly inconsistent with our Eq. (3), so we have raised the final error from 4 to 6 MeV.

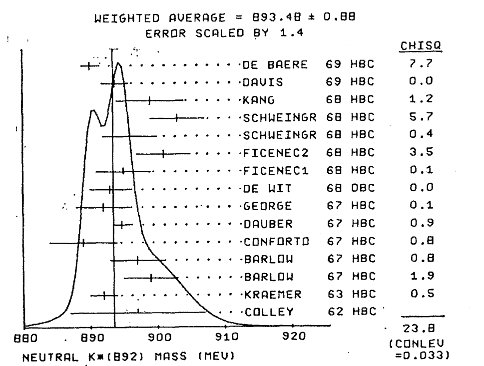
Comments on FICENEC 68: FICENEC-1 contains a disclaimer "Little significance can be attached to the mass difference ··· since the width of the K^* and the experimental resolution are large." FICENEC-2 has no such warning, even though the backgrounds and momenta are higher. We have decided to include both momenta in our averages.

Data in parentheses have not been included in our averages.

All the FICENEC errors are consistent with our Eq. (3) except the ±1 MeV on $m(K^{*0})$ in FICENEC-2. This must be a mistake, so we raised it to ±2 MeV, to agree with FICENEC-1. But then we note that χ^2 for agreement between the K^* masses of FICENEC-1 and FICENEC-2 is 4.5, where 1.0 is expected. So we have scaled up the errors on $m(K^{*0})$ by another factor of 2. The two FICENEC experiments then average to give a mass difference of 8±3.5 MeV. Because of interference questions, we doubt that it is as reliable as the 6.3±6 of BARASH 67, but the two are certainly in agreement.

```
M  MIXED-- CHARGED AND NEUTRAL. NOT TABULATED
M     200 (880.0)                    ALEXANDER 62 HBC  + 0 2.2 PI-P
M          895.0      2.0            FERRO-LUZ 65 HBC  + 0 3.0 K+P           6/66
M         (895.0)                    WANGLER   65 HBC  + 0 3.0 PI- P         6/66
M          894.       5.             FRENCH    67 HBC  +-0 3-4 PBAR P        6/67
M         . . . . . . . . . .
M   AVG    894.9      1.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M  NEUTRAL ONLY. BUT WE DONT USE THIS FOR MASS DIFF. - SEE TYPED NOTE
M      70  897.0     10.0            COLLEY    62 HBC    0 2.0 PI-P
M     200  892.0      2.0            KRAEMER   63 HBC    0 2.3 K+P
M     150 (885.0)                    SMITH     63 HBC    0 2.3 PI-P
M          899.       4.             BARLOW    67 HBC    0 1.2 PBAR P       11/66
M          897.       4.             BARLOW    67 HBC    0 1.2 PBAR P       11/66
M          889.0      5.0            CONFORTO  67 HBC    0 0. PBAR P         9/67
M          894.7      1.3            DAUBER    67 HBC    0  2.0 K- P        12/66
M          892.0      4.0            GEORGE    67 HBC    0 5.0 K+ P         11/67
M          893.       3.             DE WIT    68 DBC    0 3. K- D           9/69*
M  F       895.       4.             FICENEC1  68 HBC    0 1.3 K-P (K-PI+)  11/69*
M  F       901.       4.             FICENEC2  68 HBC    0 2.7 K- P(K-PI+)  11/69*
M  F FICENEC ERROR RAISED       SEE TYPED NOTE
M          896.0      4.0            SCHWEINGR 68 HBC    0 4.1 K-P           9/67
M          903.0      4.0            SCHWEINGR 68 HBC    0 5.5 K-P           9/67
M          899.0      5.0            KANG      68 HBC    0 4.6 K- P          7/69*
M   10700  893.7      2.0            DAVIS     69 HBC    0 12. K+ P          9/69*
M  D 2000  890.0      1.25           DE BAERE  69 HBC    0 5.0 K+ P          9/69*
M  D DE BAERE ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE TYPED NOTE.     11/69*
M         . . . . . . . . . .
M   AVG    893.48     0.88    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
                              (SEE IDEOGRAM BELOW )
```

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             18  K*(0) - K*(+-) MASS DIFF. (MEV)

D   ALL ERRORS ENLARGED BY US, SEE TYPED NOTE
D      330   6.3      6.0           BARASH    67 HBC   .0 PBAR P            8/67
D     1400   6.5      5.0           FICENEC1  68 HBC    1.3 K- P            2/69*
D     1600   9.5      5.0           FICENEC2  68 HBC    2.7 K- P            2/69*
D          . . . . . . . . . .
D   AVG      7.6      3.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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             18  K* (892) WIDTH (MEV)

W  CHARGED ONLY. THIS IS WHAT APPEARS ON MESON TABLE
W          46.0      8.0            CHADWICK  63 HBC  +  1.5 K+P
W          47.0      4.0            FERRO-LUZ 65 HBC  +  3.0 K+P
W          50.       5.             BOMSE     67 HBC  + 2.3 K+P              7/67
W          56.       4.5            DE BAERE  67 HBC  + 3.5 K+P (KO PI+)     7/67
W          53.       8.             DE BAERE  67 HBC  + 3.5 K+P (K+ PIO)     7/67
W          68.      10.             SALLSTRCM 67 HBC  + 3. K+ P (KO PI+)     7/67
W          47.      10.             SALLSTROM 67 HBC  + 3. K+ P (K+ PIO)     7/67
W          44.       7.             BARLOW    67 HBC  +-  1.2 PBAR P        11/66
W          43.       9.             BARLOW    67 HBC  +- 1.2 PBAR P         11/66
W          53.       7.             BARLOW    67 HBC  +-  1.2 PBAR P        11/66
W         (43.)                     CONFORTO  67 HBC  +-  0. PBAR P          9/67
W    3870  46.0      3.0            WOJCICKI1 64 HBC  -  1.7 K-P
W          51.0      3.0            ADELMAN   65 HBC  -  1.5 K-P             6/66
W          50.0     15.0            GELSEMA   65 HBC  -  1.5 K-P
W          58.       7.             ADERHOLZ  68 HBC  -  10 K- P             6/68
W          58.      16.             FICENEC   68 HBC  -  1.3 K-P (K-PIO)     9/67
W          44.      13.             FICENEC   68 HBC  -  1.3 K-P (KOPI-)     9/67
W          41.0      8.0            SCHWEINGR 68 HBC  -  4.1 K-P             9/67
W          47.0      4.0            SCHWEINGR 68 HBC  -  5.5 K-P             9/67
W          57.0     13.0            FICENEC   68 HBC  -  2.7 K- P(K-PIO)     2/69*
W          48.0      9.0            FICENEC   68 HBC  -  2.7 K- P(KOPI-)     2/69*
W          52.0      8.0            KANG      68 HBC  -  4.6 K- P            7/69*
W         (27.0)    (8.0)    (6.0)  ERWIN     69 HBC  +  3.5 K+ P            9/69*
W          53.       3.             FRIEDMAN  69 HBC  -  2.1  K-P (3BDY)     9/69*
W          49.       4.             FRIEDMAN  69 HBC  -  2.45 K-P (3BDY)     9/69*
W          46.       2.             FRIEDMAN  69 HBC  -  2.6  K-P (3BDY)     9/69*
W          49.       3.             FRIEDMAN  69 HBC  -  2.7  K-P (3BDY)     9/69*
W          50.       7.             LIND      69 HBC  +  9. K+ P             9/69*
W
W         . . . . . . . . . .
W   AVG    48.98     0.92     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W  MIXED-- CHARGED AND NEUTRAL. NOT TABULATED
W     200  60.0      5.0            ALEXANDER 62 HBC  + 0 2.2 PI-P
W          51.8      3.5            FERRO-LUZ 65 HBC  + 0 3.0 K+P            6/66
W         (40.0)                    WANGLER   65 HBC  + 0 3.0 PI- P          6/66
W          60.      10.             FRENCH    67 HBC  +-0 3-4 PBAR P         6/67
W         . . . . . . . . . .
W   AVG    54.9      2.8      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W  NEUTRAL ONLY.
W      70  60.0     10.0            COLLEY    62 HBC    0 2.0 PI-P
W     200  50.0      5.0            KRAEMER   63 HBC    0 2.3 K+P
W     150 (50.0)                    SMITH     63 HBC    0 2.3 PI-P
W          53.      13.             BARLOW    67 HBC    0 1.2 PBAR P        11/66
W          34.       8.             BARLOW    67 HBC    0 1.2 PBAR P        11/66
W         (43.)                     CONFORTO  67 HBC    0 0. PBAR P          9/67
W          44.       4.             DAUBER    67 HBC    0  2.0 K- P         12/66
W          58.       8.             DE WIT    68 DBC    0 3. K- D            9/69*
W          52.      12.             FICENEC   68 HBC    0 1.3 K-P (K-PI+)    9/67
W          50.0      8.0            FICENEC   68 HBC    0 2.7 K- P(K-PI+)    2/69*
W          48.0      8.0            KANG      68 HBC    0 4.6 K- P           7/69*
W          51.0     11.0            SCHWEINGR 68 HBC    0 5.5 K-P            9/67
W          53.0     11.0            SCHWEINGR 68 HBC    0 4.1 K-P            9/67
W   10700  53.2      1.6            DAVIS     69 HBC    0 12. K+ P           9/69*
W  D 2000  58.0      5.0            DE BAERE  69 HBC    0 5.0 K+ P           9/69*
W  D DE BAERE ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE TYPED NOTE.     11/69*
W         . . . . . . . . . .
W   AVG    51.9      1.3      AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

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             18  K* (892) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     K*(892) INTO K PI                                  493+ 139
P2     K*(892) INTO (K PI PI)                             493+ 139+ 139

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             18  K* (892) BRANCHING RATIOS

R1     K*(892) INTO (K PI PI)/(K PI)
R1       0   (0.002)OR LESS            WOJCICKI2 64 HBC  -  1.7 K-P

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                              REFERENCES FOR K*(892)

ALSTON   61 PRL 6 300          ALSTON,ALVAREZ,EBERHARD,GOOD,GRAZIANO+(LRL)
ALEXANDE 62 PRL 8 447          ALEXANDER,KALBFLEISCH,MILLER,G SMITH  (LRL)
COLLEY   62 CERN CONF 315      C COLLEY,N GELFAND +     (COLUMBIA+RUTGERS)

CHADWICK 63 PL 6 309           CHADWICK,CRENNELL,DAVIES,BETTINI+(OXF+PADU)
GOLDHABE 63 ATHENS CONF 92     SULAMITH GOLDHABER                     (LRL)
KRAEMER  63 ATHENS CONF 130    R KRAEMER L MADANSKY +     (JOHNS HOPKINS)
SMITH    63 PRL 10 138         SMITH,SCHWARTZ,MILLER,KALBFLEISCH,HUF+(LRL)

WOJCICK1 64 PR 135 B 484       STANLEY G WCJCICKI                     (LRL)
WOJCICK2 64 PR 135 B 495       S WOJCICKI,M ALSTON,G KALBFLEISCH      (LRL)

ADELMAN  65 ATHENS 527         STUART LEE ADELMAN               (CAVENDISH)
FERRO-LU 65 NC 36 1101         FERRO-LUZZI,GEORGE,HENRI,JONGEJANS    (CERN)
FERRO-LU 65 NC 39 417          FERRO-LUZZI,GEORGE,GOLDSCHMIDT-CLER+ (CERN)
GELSEMA  65 THESIS             E.S.GELSEMA (SEE ALSO PL 10 341)  (AMSTERD)
WANGLER  65 PR 137 B 414       WANGLER,ERWIN,WALKER             (WISCONSIN)

BARASH   67 PR  156  1399      BARASH,KIRSCH,MILLER,TAN          (COLUMBIA)
BARLOW   67 NC  50 A  701      +MONTANET,D-ANDLAU+(CERN+CDF+IOR+LIVERPOOL)
BOMSE    67 PR 158 1298        +BORENSTEIN+COLE+GILLESPIE+  (JOHN HOPKINS)
CONFORTO 67 NP B3 469          +MARECHAL,MONTANET+ (CERN+CF+IPN+LIVERPOOL)
DAUBER   67 PR 153 1403        +SCHLEIN,SLATER,TICHO                 (UCLA)
DE BAERE 67 NC 51 A 401        +GOLDSCHMIDT-CLERMONT,HENRI+    (BRUX+CERN)
FRENCH   67 NC 42A 442         +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
GEORGE   67 NC 49A 9           +GOLDSCHMIDT-CLERMONT+HENRI+    (CERN+BRUX)
SALLSTRO 67 NC 49A 348         SALLSTROM+OTTER+EKSPONG         .(STCCKHOLM)

ADERHOLZ 68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+I.C.+VIENNA)
DE WIT   68  THESIS            S. DE WIT                         (AMSTERDAM)
FICENEC1 68 PR 169 1034        +HULSIZER+SWANSCN+TROWER             (URBANA)
FICENEC2 68 PR 175 1725        FICENEC, GORDON, TROWER            (ILLINOIS)
KANG     68 PR 176 1587        Y.W.KANG                               (IOWA)
SCHWEING 68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS,AMMAR+(ANL+NW)

CRENNELL 69 PRL 22  487        +KARSHON,LAI,ONEALL,SCARR               (BNL)
DAVIS    69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE 69 NC 61 A 397        +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG   (WISC+PRIN+VAND)
FRIEDMAN 69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS                (LRL)
LIND     69  UCRL 19284        +ALEXANDER,FIRESTONE,FU,GOLDHABER      (LRL)

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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

$K_N(1080-1260)$ $\rightarrow K\pi$

19 KN(1080-1260)

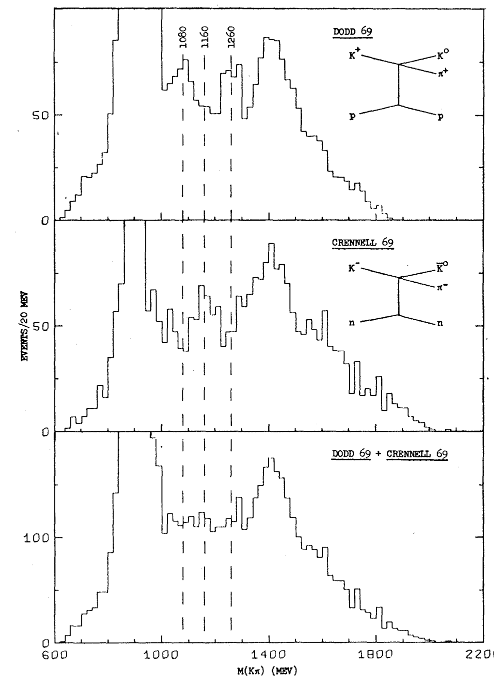
OMITTED FROM TABLE.

Note on $K_N(1080\text{-}1260)$

From a study of $K^+p \rightarrow K\pi\Delta^{++}$, TRIPPE 68 find that the I = 1/2 S-wave phase shift increases smoothly from threshold and reaches about 90 deg in the region 1100-1200 MeV. If interpreted as a resonance the width is about 400 MeV. However, there is no convincing evidence that the S-wave phase shift continues past 90 deg above 1100-1200 GeV (SCHLEIN 69).

By compiling ~ 500 events $K^+p \rightarrow K_1\pi^+p$ produced between 3 and 3.5 GeV/c, DODD 69 see an excess of $K\pi$ events at 1080 MeV and a 4.6-standard deviation peak at 1260 MeV with $\Gamma \approx$ 70 MeV; however, CRENNELL 69 have 3000 $K^-n \rightarrow K_1\pi^-n$ produced at 3.9 GeV/c and see a 5-standard deviation peak in between, at M = 1160, Γ = 90. These effects tend to cancel, as shown in the separate and combined histograms below. Can one reasonably compare these two histograms, for which both the energies and the reactions are somewhat different? If the two spectra had been similar, one would take them to be positive evidence for resonances. To this extent, then, it is always reasonable to compare similar spectra, and to be slightly discouraged if they are dissimilar. Further, if DODD 69 base their claim on agreement between spectra at 3.0 and 3.5 GeV, one might hope for agreement between 3.5 and 3.9.

The other difference between these experiments is that one is $K^+p \rightarrow \pi^+p\,K^0$, the other $K^-n \rightarrow \pi^-n\,\overline{K}^0$. Their t-channel diagrams are sketched above each histogram. The two upper vertices are charge conjugate (hence similar), but the first experiment is subject to a K^0p final-state interference, the second to a different $\overline{K}^0n$ interference. These could perhaps explain a difference in the spectra.



REFERENCES FOR KN(1080-1260)

DE BAERE 67 NC 51 A 401 +DEBAISIEUX,GOLDSCHMIDT-CLERM.+ (CERN+BRUX)
TRIPPE 68 PL 28 B 203 +CHIEN,MALAMUD,MELLEMA,SCHLEIN,+ (UCLA)
CRENNELL 69 PRL 22 487 +KARSHON,LAI,O.NEALL,SCARR (BNL)
DODD 69 PR 177 1994 +JOLDERSMA,PALMER,SAMIOS (BNL)
SCHLEIN 69 UCLA 1040 P.SCHLEIN (UCLA)

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$K_{A,I=3/2}(1175)$

24 KA 3/2 (1175,JP=) I = 3/2

EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.
FOR A DISCUSSION SEE ROSENFELD 68

REFERENCES FOR KA3/2(1175)

WANGLER 64 PL 9 71 T P WANGLER,A R ERWIN,W D WALKER (WISCONS)
MILLER 65 PL 15 74 MILLER,KOVACS,MCILWAIN,PALFREY + (PURDUE)
ROSENFEL 68 PROC. PHILA. CONF ON MESON SPECTROSCOPY. P. 455. UCRL 18266
DODD 69 PR 177 1991 +JOLDERSMA, PALMER, SAMIOS (BNL)

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$K_{A,I=3/2}(1265)$

25 KA3/2(1265,JP=) I=3/2

EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.
FOR A DISCUSSION SEE ROSENFELD 68

REFERENCES FOR K*3/2 (1265)

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FRENCH   67 NC 52A 442        +KINSON+MCDONALD+RIDDIFORD+     (CERN+BIRM)
ROSENFEL 68 PROC. PHILA. CONF ON MESON SPECTROSCOPY. P. 455. UCRL 18266
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Q REGION, $K\pi\pi(1200-1350)$

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THERE EXIST MANY PAPERS REPORTING A BROAD I=1/2 (K PI PI) ENHANCEMENT IN THE MASS REGION 1200-1350 MEV. IT IS PROBABLY DUE TO SOME COMBINATION OF DECK EFFECT AND ONE, TWO, OR THREE REAL RESONANCES. FOR CONVENIENCE OF PRESENTATION, WE HAVE GROUPED THE DATA UNDER THE NAM OF THREE PARTICLES AND ONE PSEUDO-PARTICLE, RESPECTIVELY KA(1240), KA(1280), KA(1320), AND KA(1200-1350). UNDER THE LAST CATEGORY WE HAVE LISTED ALL EXPERIMENTS THAT REPORT A BROAD PEAK, WITH A WIDTH GREATER THAN 100 MEV.

Data in parentheses have not been included in our averages.

$K_A(1200-1350)$

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28  KA(1200-1350)  I=1/2
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                  28  KA(1200-1350) MASS  (MEV)

M      200 1280.     20.           BERLINGHI 67 HBC  +   12.7 K+ P       7/67
M   B      BERLINGHIERI VALUE IS FROM (K* PI) MODE. THE (K RHO) MASS
M   B      PEAKS AT 1320, AN EFFECT THAT THEY ATTRIBUTE TO KINEMATICS
M   B                                     NEAR (K RHO) THRESHOLD.
M         (1270.)   APPROX.        DE BAERE  67 HBC  + 3.5 K+ P          7/67
M   A     (1325.0)    (6.0)        BARTSCH   68 HBC     10. K-P,K 2PI    9/69*
M   A      ALREADY INCLUDED IN K NPI SAMPLE BELOW
M          1335.0      6.0         BARTSCH   68 HBC     10. K-P,K NPI    9/69*
M         (1300.)   APPROX.        BARBARO   69 HBC  +  12.K+ P (K 2PI)  9/69*
M          . . . . . . . . . .
M   AVG    1330.5     15.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.6)

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                  28  KA(1200-1350) WIDTH (MEV)

W      200  130.      15.          BERLINGHI 67 HBC  +   12.7 K+ P       7/67
W          (200.)   APPROX.        DE BAERE  67 HBC  + 3.5 K+ P          7/67
W   A      (186.0)   (15.0)        BARTSCH   68 HBC     10. K- P,K 2PI   9/69*
W   A       SEE NOTE UNDER MASS ABOVE
W           196.0     16.0         BARTSCH   68 HBC     10. K- P,K NPI   9/69*
W          (250.)   APPROX.        BARBARO   69 HBC  +  12.K+ P (K 2PI)  9/69*
W           . . . . . . . . . .
W   AVG     160.9     32.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.0)

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                  28  KA(1200-1350) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1         KA(1200-1350) INTO K*(890) PI               493+ 139+ 139
P2         KA(1200-1350) INTO K RHO                    493+ 139+ 139
P3         KA(1200-1350) INTO K PI                     493+ 139+ 139
P4         KA(1200-1350) INTO K ETA                    493+ 139+ 139
P5         KA(1200-1350) INTO K OMEGA                  493+ 139+ 139
P6         KA(1200-1350) INTO K PI PI                  497+ 139+ 139

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                  28  KA(1200-1350) BRANCHING RATIOS

R1         KA(1200-1350) INTO K*(890) PI ANC K RHO (OVERLAPPING BANDS)
R1     200  (1.0)                  BERLINGHI 67 HBC  +   12.7 K+ P       7/67

R2         KA(1200-1350) INTO (K PI) / TOTAL
R2          (0.02) OR LESS         BERLINGHI 67 HBC  +   12.7 K+ P      11/67
R2          (0.02) OR LESS, C.L.=.95 ABCLV COL 68 HBC  - 10.0 K- P       9/68

R3         KA(1200-1350) INTO (K ETA) / TOTAL
R3          (0.02) OR LESS         BERLINGHI 67 HBC  +   12.7 K+ P      11/67

R4         KA(1200-1350) INTO (K OMEGA) / TCTAL
R4          (0.02) OR LESS         BERLINGHI 67 HBC  +   12.7 K+ P      11/67
R4      12  (0.01)    (0.005)      ABCLV CCL 68 HBC   - 10.0 K- P        9/68

R5         KA(1200-1350) INTO (K RHO) / (K*(890) PI)
R5           0.91      0.25        BERLINGHI 67 HBC  +   12.7 K+ P      11/67
R5     701  (0.4)     (0.1)        ABCLV COL 68 HBC   - 10.0 K- P        9/68

R6         KA(1200-1350) INTO (K PI) / (K*(890) PI)
R6          (0.21) OR LESS         DE BAERE  67 HBC  +   3.5 K+ P       11/66

R7         KA(1200-1350) INTO (K PI PI) / TCTAL
R7     201  (0.22)    (0.08)       ABCLV COL 68 HBC   - 10.0 K- P        9/68

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                      REFERENCES FOR KA (1200-1350)

BERLINGH 67 PRL 18 1087       BERLINGHIERI+FARBER+FERBEL+FORMAN+    (ROCH)IJP
DE BAERE 67 NC 49A 374        +DEBAISIEUX+FAST+FILIPPAS+       (CERN+BRUX)
   AND PRIVATE COMMUNICATION BY B. JONGEJANS
BARTSCH  68 NP 88 9           +COCCONI,+         (AACH+BERL+CERN+LOIC+IHAW)
BOMSE    68 PRL 20 1519       +BORENSTEIN,CALLAHAN,COLE,COX,+  (JOHNHOPK)  1+
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+   (JCHNHOPK)  1+
ANDREWS  69 PRL 22 731        +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO  69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+        (LRL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)

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$K_A(1240)$ or C

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20  KA (1240,JP=  )  I=1/2

NAMED C BY ASTIER 69.  JP=1+ STRONGLY FAVORED.
0- AND 2- (P-WAVE DECAY) ARE EXCLUDED (ASTIER 69).

SEE NOTE PRECEDING KA(1200-1350)

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                  20  KA (1240)  MASS (MEV)

M          1230.0     15.0             BASSOMPIE 67 HBC  +   5. K+ P    11/67
M          1250.0     10.0             GOLDHABER 67 HBC     9.0 K+ P    10/67
M          1242.0      9.0     10.0    ASTIER    69 HBC    0 PBAR P      9/69*
M   A      ERRORS OF ASTIER 69 ARE STATISTICAL. TRUE UNCERTAINTY IS LARGER
M          . . . . . . . . . .
M   AVG    1243.0      6.3     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.0)

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                  20  KA (1240) WIDTH (MEV)

W            60.0     20.0             BASSOMPIE 67 HBC  +   5. K+ P    11/67
W            50.0     20.0             GOLDHABER 67 HBC     9.0 K+ P    10/67
W           127.0      7.0     25.0    ASTIER    69 HBC    0 PBAR P      9/69*
W   A      ERRORS OF ASTIER 69 ARE STATISTICAL. TRUE UNCERTAINTY IS LARGER
W          . . . . . . . . . .
W   AVG      86.6     25.4     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 2.4)
                         (SEE IDEOGRAM BELOW )
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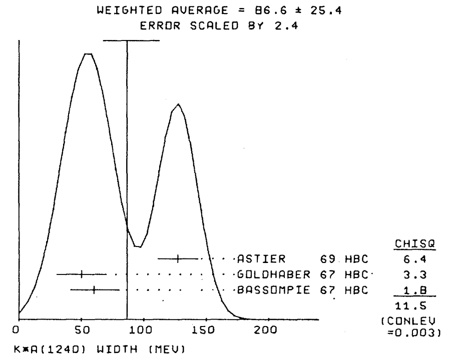


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                  20  KA (1240) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1       KA INTO K RHO                                   493+ 765
P2       KA INTO K* PI                                   892+ 139
P3       KA INTO K PI PI                                 497+ 139+ 139

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                  20  KA (1240) BRANCHING RATIOS

R1       KA(1240) INTO (K RHO)/TOTAL  (UNITS OF 10**-2)
R1            75.0      10.0          ARMENTERO 64 HBC      0.0 PBAR P      6/66

R2       KA(1240) INTO (K* PI)/TOTAL  (UNITS OF 10**-2)
R2            25.0      10.0          ARMENTERO 64 HBC      0.0 PBAR P      6/66

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                       REFERENCES FOR KA (1240)

ARMENTER 64 DUBNA CONF 1 577  ARMENTEROS,EDWARCS,C-ANDLAU +     (CERN+CDF)
                         SEE ALSO PL 9, 207
    ALSO     DUBNA CCNF 1 617  R ARMENTEROS (RAPPORTEUR)
    ALSO 66 PR  145  1095      BARASH,KIRSCH,MILLER,TAN         (COLUMBIA)
BASSOMPI 67 PL 26B 30          BASSOMPIERRE,GOLOSCHMIDT+  (CERN+BRUX+BIRM)IJP
GOLDHABE 67 PRL 19  972        G.GOLDHABER,FIRESTCNE,SHEN              (LRL)

ALEXANDE 69  UCRL-18872        G.ALEXANDER,FIRESTONE,GOLDHABER,+      (LRL)
ASTIER   69 NP B 10 65         +MARECHAL,MCNTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BETTINI  69 NC 62 A 1038       +CRESTI,LIMENTANI,BERTAUZA,BIGI+(PADO+PISA)I

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$K_A(1280)$

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26  KA(1280,JP=  ) I=1/2

SOME OF THE PEAKS LISTED MAY BE BETTER ASSOCIATED WITH
EITHER THE KA(1240) OR THE KA(1320).
SEE NCTE PRECEDING KA(1200-1350)

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                  26  KA(1280) MASS  (MEV)

M        (1280.0)                  SHEN      66 HBC  + 0 4.6 K+P,5 BODY  11/67
M      35 1280.0     10.0          BASSOMPIE 67 HBC  +   5. K+ P         11/67
M      45(1300.)                   CRENNELL  67 HBC    0 6 PI- P          7/67
M         1250.0     10.0          GCLDHABER 67 HBC      9.0 K+ P        10/67
M      45 1301.0     10.0          BISHOP    69 HBC  +   3.5 K+P(K* PI)   9/69*
M      21 1300.0     10.0          ERWIN     69 HBC    0 3.5 K+P(K* PI)   9/69*
M         1281.       7.           FRIEDMAN  69 HBC  --  2.6,2.7 K- P     9/69*
M         . . . . . . . . . .
M   AVG   1282.2      8.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.1)
                        (SEE IDEOGRAM BELOW )

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                  26  KA(1280) WIDTH (MEV)

W          100.0     20.0          SHEN      66 HBC  + 0 4.6 K+P,5 BODY  11/67
W      35   80.0     20.0          BASSOMPIE 67 HBC  +   5. K+ P         11/67
W      45  (60.)                   CRENNELL  67 HBC    0 6 PI- P          7/67
W           50.0     20.0          GOLDHABER 67 HBC      9.0 K+ P        10/67
W      45   40.0     10.0          BISHOP    69 HBC  +   3.5 K+P(K* PI)   9/69*
W      21   40.0     15.0          ERWIN     69 HBC    0 3.5 K+P(K* PI)   9/69*
W           51.      22.           FRIEDMAN  69 HBC  -   2.6,2.7 K- P     9/69*
W         . . . . . . . . . .
W   AVG     52.4      9.0     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.4)
                        (SEE IDEOGRAM BELOW )

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                  26  KA (1280) PARTIAL DECAY MODES

                                                         DECAY MASSES
P1         KA INTO K*(890) PI                            892+ 139
P2         KA INTO K RHO                                 497+ 765
P3         KA INTO K OMEGA                               497+ 783
P4         KA INTO K PI                                  493+ 139
P5         KA INTO K ETA                                 493+ 548

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                  26  KA (1280) BRANCHING RATIOS

R1         KA(1280) INTO (K PI) / (K*(890) PI)
R1          (0.8)  OR LESS         SHEN      66 HBC      4.6 K+P, 5 BODY  11/67
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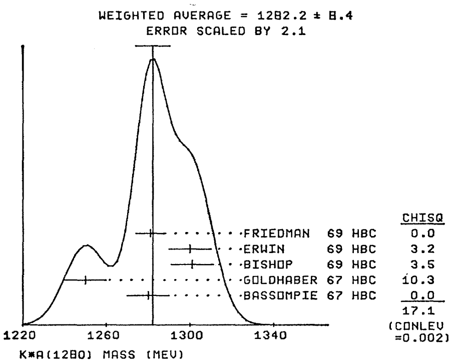
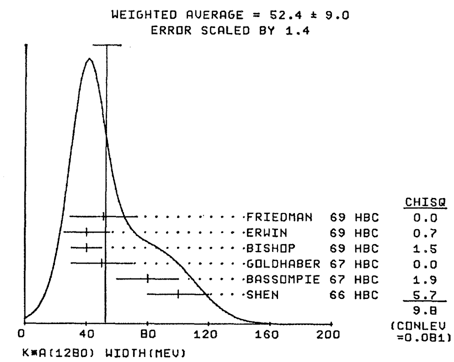
Data in parentheses have not been included in our averages.





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REFERENCES FOR KA(1280)

SHEN 66 PRL 17 726 +BUTTERWORTH,FU,GOLDHABERS,TRILLING (LRL)
BASSOMPI 67 PL 26B 30 BASSOMPIERRE,GOLDSCHMIDT+ (CERN+BRUX+BIRM)IJP
CRENNELL 67 PRL 19 44 +KALBFLEISCH,LAI,SCARR,SCHUMANN (BNL)I
GOLDHABE 67 PRL 19 972 G.GOLDHABER,FIRESTONE,SHEN (LRL)

ALEXANDE 69 UCRL-18872 G.ALEXANDER,FIRESTONE,GOLDHABER,+ (LRL)
BISHOP 69 NP B 9 403 +GOSHAW,ERWIN,WALKER (WISC)
ERWIN 69 NP B 9 364 +WALKER,GOSHAW,WEINBERG (WISC+PRIN+VAND)
FRIEDMAN 69 UCRL-18860 J.FRIEDMAN,PH.D. THESIS (LRL)

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$K_A(1320)$

21 KA (1320,JP=) I=1/2

SOME OF THE PEAKS LISTED MAY BE BETTER ASSOCIATED WITH THE KA(1280).
SEE NOTE PRECEDING KA(1200-1350)
(JP = 1+ FAVORED)

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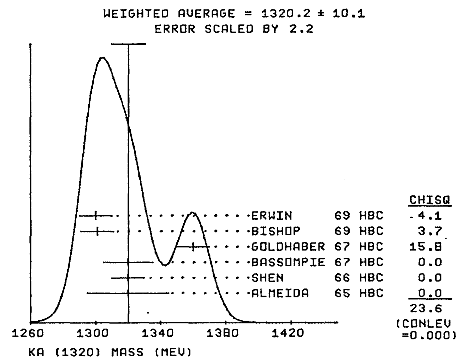
21 KA (1320) MASS (MEV)

M	12	1320.0	25.0	ALMEIDA	65	HBC	+		3-5 K+ P	8/66
M	70	1320.0	10.0	SHEN	66	HBC	+		4.6 K+ P	8/66
M		(1280.0)		SHEN	66	HBC	+	0	4.6 K+P,5 BODY	11/67
M		1320.0	15.0	BASSOMPIE	67	HBC	+		5. K+ P	11/67
M	45	(1300.)		CRENNELL	67	HBC		0	6 PI- P	7/67
M		1360.0	10.0	GOLDHABER	67	HBC			9.0 K+ P	10/67
M	45	1301.0	10.0	BISHOP	69	HBC	+		3.5 K+P(K* PI)	9/69*
M	21	1300.0	10.0	ERWIN	69	HBC		0	3.5 K+P(K* PI)	9/69*
M		. . . .								
M	AVG	1320.2	10.1	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)						

(SEE IDEOGRAM BELOW)



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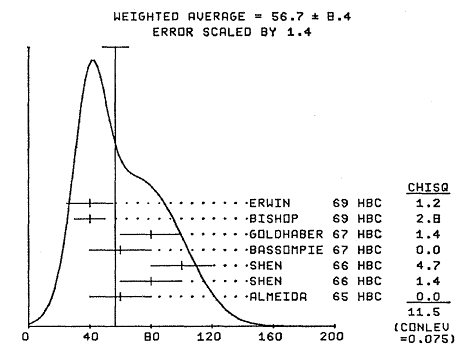
21 KA (1320) WIDTH (MEV)

W	12	60.0	20.0	ALMEIDA	65	HBC	+		3-5 K+P	8/66
W	70	80.0	20.0	SHEN	66	HBC	+		4.6 K+P	8/66
W		100.0	20.0	SHEN	66	HBC	+	0	4.6 K+P,5 BODY	11/67
W		60.0	20.0	BASSOMPIE	67	HBC	+		5. K+ P	11/67
W	45	(60.)		CRENNELL	67	HBC		0	6 PI- P	7/67
W		80.0	20.0	GOLDHABER	67	HBC			9.0 K+ P	10/67
W	45	40.0	10.0	BISHOP	69	HBC	+		3.5 K+P(K* PI)	9/69*
W	21	40.0	15.0	ERWIN	69	HBC		0	3.5 K+P(K* PI)	9/69*
W		. . . .								
W	AVG	56.7	8.4	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)						

(SEE IDEOGRAM BELOW)



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21 KA (1320) PARTIAL DECAY MODES

P2	KA INTO K RHO	497+ 765
P3	KA INTO K OMEGA	497+ 783
P4	KA INTO K PI	493+ 139
P5	KA INTO K ETA	493+ 548
		DECAY MASSES
P1	KA INTO K*(890) PI	892+ 139

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21 KA (1320) BRANCHING RATIOS

R1 * KA INTO K*(890) PI AND K RHO (OVERLAPPING BANDS)
R1 70 (1.0) SHEN 66 HBC + 4.6 K+P 8/66

R2 KA INTO(K OMEGA)/(K*(890) PI)
R2 (0.1) OR LESS SHEN 66 HBC + 4.6 K+P 10/66

R8 KA (1320) INTO (K PI) / (K*(890) PI)
R8 (0.30) OR LESS SHEN 66 HBC + 4.6 K+P 10/66

R9 KA (1320) INTO (K+ PI-) / (K+0 PIO+ PI-)
R9 (0.2) OR LESS (CL=.90) CRENNELL 67 HBC 0 6.0 PI-P 7/67

R10 KA (1320) INTO (KO PI+ PI- PIO) / (K+0 PIO+ PI-)
R10 (0.1) OR LESS (CL=.90) CRENNELL 67 HBC 0 6.0 PI-P 7/67

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Data in parentheses have not been included in our averages.

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                              REFERENCES FOR KA(1320)

ALMEIDA  65 PL 16 184          ALMEIDA,ATHERTON,BYER,DORNAN,FORSON+(CAMBR)
SHEN     66 PRL  17  726       +BUTTERWORTH,FU,GOLDHABERS,TRILLING    (LRL)
   ALSO 66  (PRIVATE COMMUN)GERSON GOLDHABER                          (LRL)
BASSOMPI 67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
CRENNELL 67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN        (BNL)I
GOLDHABE 67 PRL 19  972        G.GOLDHABER,FIRESTONE,SHEN             (LRL)

ALEXANDE 69  UCRL-18872        G.ALEXANDER,FIRESTONE,GOLDHABER,+      (LRL)
ASTIER   69 NP B 10 65         +MARECHAL,MONTANET,+  (CDEF+CERN+IPNP+LIVP)IJP
BISHOP   69 NP B 9 403         +GOSHAW,ERWIN,WALKER                  (WISC)
ERWIN    69 NP B 9 364         +WALKER,GOSHAW,WEINBERG    (WISC+PRIN+VAND)

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$K_N(1420)$

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22  KN (1420,JP=2+) I=1/2

JP = 3- IS UNLIKELY BUT NOT YET COMPLETELY RULED OUT.

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                22 KN(1420) MASS (MEV)

M   FOR DIFFICULTIES IN MEASURING MASS DIFFERENCE, SEE TYPED NOTE UNDER K*

M   CHARGED ONLY
M         1400.0     20.0              BADIER    65 HBC  -  3.  K- P (K*PI) 10/66
M         1427.      15.0              DE BAERE  67 HBC  + 3.5 K+P (KO PI+) 10/66
M         1440.      24.0     40.      DE BAERE  67 HBC  + 3.5 K+P (K+ PIO) 10/66
M         1423.      21.               ADERHOLZ  68 HBC  -  10 K- P (K PI)   6/68
M      20 1440.0     20.0              DUBAL     68 MMS  -  11.5 K- P        6/68
M         1401.0      8.0              SCHWEINGR 68 HBC  -  4.1 K- P (K PI)  9/67
M         1427.0      9.0              SCHWEINGR 68 HBC  -  5.5 K- P (K PI)  9/67
M  B  125 1396.       9.               BASSOMPIE 69 HBC  +  5 K+P (K PI)    11/69*
M  B  240 1396.       6.               BASSOMPIE 69 HBC  +  5 K+P (K 2PI)   11/69*
M         1425.0     15.0              BISHOP    69 HBC  +  3.5 K+ P         9/69*
M         1416.0     10.0              CRENNELL  69 DBC  -  3.9 K-N (KOPI-)  7/69*
M         1411.       7.               FRIEDMAN  69 HBC  -  2.7 K-P (K 2PI)  9/69*
M         1414.      11.               LIND      69 HBC  +  9. K+ P          9/69*
M         . . . . . . . . .
M   AVG   1409.0      3.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
                           (SEE IDEOGRAM BELOW )

M   CHARGED AND NEUTRAL
M         1404.0     15.0              FOCARDI   65 HBC  -0 3.  K- P (K PI) 10/66
M         1390.0     30.0              SHEN      66 HBC  + 0 4.6 K+ P (K PI) 10/66
M         1430.0     10.0              SHEN      66 HBC  + 0 4.6 K+ P (K*PI) 10/66
M         1423.0      7.0              BASSANO   67 HBC  -0 4.6, 5.0 K- P   10/67
M         1420.0     10.0              GOLDHABER 67 HBC     9.0 K+ P(K 2PI) 10/67
M         . . . . . . . . .
M   AVG   1421.2      4.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

M   NEUTRAL ONLY
M        (1440.)                       CRENNELL  67 HBC   0 6 PI- P (K 2PI)  7/67
M         1446.0      7.9              DAHL      67 HBC   0 4.PI- P (KPI)   10/66
M         1425.0     15.0              KANG      68 HBC   0 4.6 K- P         7/69*
M         1405.0     18.0              SCHWEINGR 68 HBC   0 4.1 K- P (K PI)  9/67
M         1397.0     19.0              SCHWEINGR 68 HBC   0 5.5 K- P (K PI)  9/67
M  B  420 1422.       5.               BASSOMPIE 69 HBC   0 5 K+P (K PI)    11/69*
M  B BASSOMP. ERRORS ENLARGED BY US TO   GAMMA/SQRT(N). SEE K* TYPED NOTE.  11/69*
M    2200 1421.1      2.6              DAVIS     69 HBC   0 12. K+ P(K+PI-)  9/69*
M         . . . . . . . . .
M   AVG   1422.7      3.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
                           (SEE IDEOGRAM BELOW )

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                22  KN(1420) WIDTH (MEV)

W   CHARGED ONLY
W          105.0     30.0              BADIER    65 HBC  -  3.0 K-P          6/66
W           90.0     28.0              DE BAERE  67 HBC  +  3.5 K+ P        10/66
W          175.      57.               ADERHOLZ  68 HBC  -  10 K- P (K PI)   6/68
W  B  125  123.      35.               BASSOMPIE 69 HBC  +  5 K+P (K PI)    11/69*
W  B  240  110.      25.               BASSOMPIE 69 HBC  +  5 K+P (K 2PI)   11/69*
W          110.0     25.0              BISHOP    69 HBC  +  3.5 K+ P         9/69*
W           43.      13.               FRIEDMAN  69 HBC  -  2.7 K-P (K 2PI)  9/69*
W          107.      19.               LIND      69 HBC  +  9. K+ P          9/69*
W         . . . . . . . . .
W   AVG     83.7     12.9     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.6)
                           (SEE IDEOGRAM BELOW )

W   CHARGED AND NEUTRAL
W           92.0     14.0              FOCARDI   65 HBC  -0 3.0 K- P (K PI)
W           75.0     25.0              SHEN      66 HBC  + 04.6 K+ P          8/66
W           65.0     20.0              BASSANO   67 HBC  -0 4.6, 5.0 K- P   10/67
W           80.0     20.0              GOLDHABER 67 HBC     9.0 K+ P(K 2PI) 10/67
W          107.0     20.0              SCHWEINGR 68 HBC  -0 4.1+5.5 K-P      9/67
W         . . . . . . . . .
W   AVG     85.9      8.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

W   NEUTRAL ONLY
W           61.0     24.0              DAHL      67 HBC   0 3.8-4.2 PI- P    9/66
W          116.0     17.0              KANG      68 HBC   0 4.6 K- P         7/69*
W  B  420  110.      21.               BASSOMPIE 69 HBC   0 5 K+P (K PI)    11/69*
W  B BASSOMP. ERRORS ENLARGED BY US TO 4*GAMMA/SQRT(N). SEE K* TYPED NOTE.  11/69*
W    2200  101.      10.               DAVIS     69 HBC   0 12. K+ P (K PI)  9/69*
W         . . . . . . . . .
W   AVG    101.2      8.4     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

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                22  KN (1420) PARTIAL DECAY MODES

                                                        DECAY MASSES
P1        KN(1420) INTO K PI                            493+ 139
P2        KN(1420) INTO K*(890) PI                      892+ 139
P3        KN(1420) INTC K RHO                           493+ 765
P4        KN(1420) INTC K OMEGA                         493+ 783
P5        KN(1420) INTO K ETA                           493+ 548

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                22  KN(1420) BRANCHING RATIOS

R1       KN(1420) INTO (K PI)/TOTAL
R1  R       (0.37)   (0.19)        BADIER    65 HBC     3.0 K-P          6/66
R1  R       (0.39)   (0.11)        BASSANO   67 HBC  -  4.6, 5.0 K- P   10/67
R1  R        THIS BRANCHING RATIO CONTAINS REDUNDANT INFORMATION, SINCE
R1  R        WE CONSTRAIN THE SUM OF ALL BRANCHING RATIOS TO BE 1.0
R1          . . . . . . . . .
R1  FIT      0.492    0.034    VALUE FROM CONSTRAINED FIT
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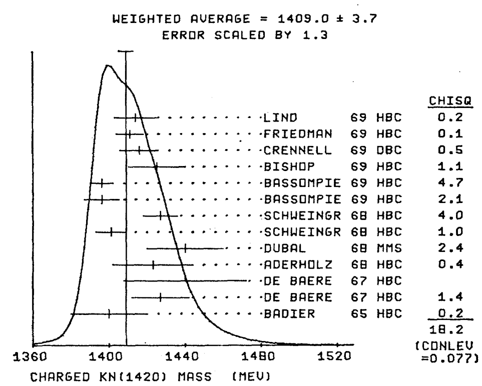

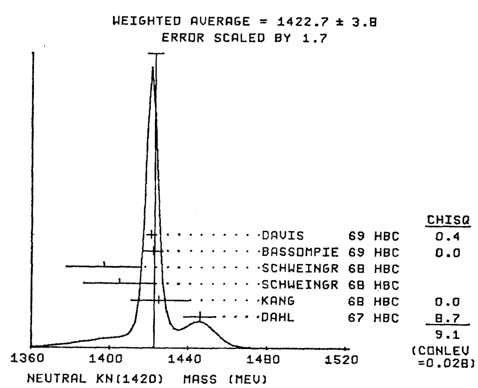

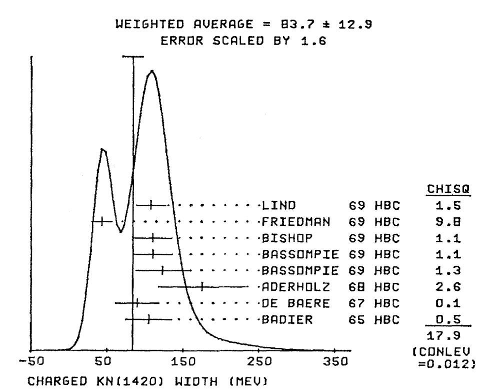

See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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R2        KN(1420) INTO (K*(890) PI) / TOTAL
R2             .41      0.14            BADIER    65 HBC       3.0 K-P          6/66
R2            0.47      0.10            BASSANO   67 HBC   -  4.6, 5.0 K- P    10/67
R2          . . . . . . . . .
R2  AVG       0.450     0.081   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT       0.363     0.031    VALUE FROM CONSTRAINED FIT

R3        KN(1420) INTO (K RHO)/TOTAL
R3            0.14      0.05            BADIER    65 HBC       3.0 K-P          6/66
R3            0.14      0.10            BASSANO   67 HBC    0 4.6, 5.0 K- P    10/67
R3          . . . . . . . . .
R3  AVG       0.140     0.045   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT       0.080     0.035    VALUE FROM CONSTRAINED FIT

R4        KN(1420) INTO (K OMEGA)/TOTAL
R4            0.07      0.04            BADIER    65 HBC       3.0 K-P          6/66
R4          . . . . . . . . .
R4  FIT       0.042     0.013    VALUE FROM CONSTRAINED FIT

R5        KN(1420) INTO (K ETA)/TOTAL
R5            0.02      0.02            BADIER    65 HBC       3.0 K-P          6/66
R5          . . . . . . . . .
R5  FIT       0.022     0.013    VALUE FROM CONSTRAINED FIT

R6        KN(1420) INTO (K*(890) PI) / (K PI)
R6        6   0.33      0.33            CHUNG     65 HBC  + 0  3.9-4.2 PI- P    8/66
R6            0.65      0.20            SHEN      66 HBC    0  N* PRODUCED     10/66
R6            0.63      0.20            SHEN      66 HBC  +    NO N* PRODUCED  10/66
R6            0.52      0.12            SCHWEINGR 68 HBC    0 4.1+5.5 K- P   10/67
R6            0.9       0.2             BASSOMPIE 69 HBC  + 0 5 K+P           9/69*
R6       84   0.93      0.11            BISHOP    69 HBC       3.5 K+ P       9/69*
R6          . . . . . . . . .
R6  AVG       0.722     0.087   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R6  FIT       0.738     0.099    VALUE FROM CONSTRAINED FIT
                                (SEE IDEOGRAM BELOW )
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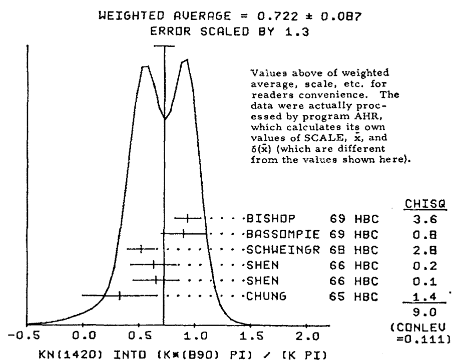


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R7        KN(1420) INTO (K OMEGA) / K PI
R7          (0.08) OR LESS              SHEN      66 HBC       4.6 K+P          8/66
R7          (0.2)  OR LESS              BASSOMPIE 69 HBC  +    5 K+ P           9/69*
R7           0.13      0.07             BASSOMPIE 69 HBC    0 5 K+ P            9/69*
R7          . . . . . . . . .
R7  FIT       0.086     0.029    VALUE FROM CONSTRAINED FIT

R8        KN(1420) INTO (K RHO) / (K PI)
R8          (0.09) OR LESS              CHUNG     65 HBC  + 0  3.9-4.2 PI- P    8/66
R8           0.26      0.16             SCHWEINGR 68 HBC    0 4.1+5.5 K- P   10/67
R8          (0.2)  OR LESS              BASSOMPIE 69 HBC  +    5 K+ P           9/69*
R8          (0.3)  OR LESS              BASSOMPIE 69 HBC    0 5 K+ P            9/69*
R8       15  0.11      0.06             BISHOP    69 HBC       3.5 K+ P         9/69*
R8          . . . . . . . . .
R8  AVG       0.128     0.056   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R8  FIT       0.163     0.076    VALUE FROM CONSTRAINED FIT

R9        KN(1420) INTO (K RHO) / (K*(890) PI)
R9          (0.39) OR LESS   .          BASSOMPIE 67 HBC  +   5. K+ P           9/67
R9          (0.40) OR LESS  (CL=.90)    FIELD     67 HBC  - 3.8 K- P            6/67
R9          . . . . . . . . .
R9  FIT       0.22      0.11     VALUE FROM CONSTRAINED FIT

R10       KN(1420) INTO (K OMEGA) / (K*(890) PI)
R10           0.10      0.04            FIELD     67 HBC  - 3.8 K- P            6/67
R10         . . . . . . . . .
R10 FIT       0.116     0.038    VALUE FROM CONSTRAINED FIT

R11       KN(1420) INTO (K ETA) / (K*(890) PI)
R11           0.07      0.04            FIELD     67 HBC  - 3.8 K- P            6/67
R11         . . . . . . . . .
R11 FIT       0.062     0.036    VALUE FROM CONSTRAINED FIT

R12       KN(1420) INTO (K ETA) / (K PI)
R12         (0.025)OR LESS              BASSOMPIE 69 HBC       5.0 K+ P         9/68
R12         (0.02) OR LESS              BISHOP    69 HBC       3.5 K+ P         9/69*


          P 1        P 2        P 3        P 4        P 5

 P 1 .492+-.034
 P 2   -.530    .363+-.031
 P 3   -.367     -.417    .080+-.035
 P 4   -.361     -.007     -.126    .042+-.013
 P 5   -.086     -.169     -.043     -.051    .022+-.016

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                                   REFERENCES FOR KN(1420)

BADIER   65 PL 19 612          BADIER,DEMOULIN,GOLDBERG+ (EP+SACLY+ZEEMAN)
CHUNG    65 PRL  15  325       +DAHL,HARDY,HESS,JACOBS,KIRZ,MILLER   (LRL)
FOCARDI  65 PL 16 351          FOCARDI,MINGUZZI RANZI,SERRA+ (BOLOGNA+CEN)

SHEN     66 PRL  17  726       +BUTTERWORTH,FU,GOLDHABERS,TRILLING   (LRL)
    ALSO 66  (PRIVATE COMMUN)GERSON GOLDHABER                        (LRL)

BASSANO  67 PRL  19  968       +GOLDBERG,GOZ,BARNES,LEITNER+(BNL+SYRACUSE)
BASSOMPI 67 PL 26B 30          BASSOMPIERRE,GOLDSCHMIDT+  (CERN+BRUX+BIRM)IJP
CRENNELL 67 PRL 19  44         +KALBFLEISCH,LAI,SCARR,SCHUMANN        (BNL)
DAHL     67 PR 163 1377        +HARDY+HESS+KIRZ+MILLER                (LRL)
    ALSO 65 PRL 14 401         HARDY,CHUNG,DAHL,HESS,KIRZ,MILLER      (LRL)
DE BAERE 67 NC 51 A 401        +GOLDSCHMIDT-CLERMONT,HENRI+     (BRUX+CERN)
FIELD    67 PL 24B 638         +HENDRICKS+PICCIONI+YAGER          (LAJOLLA)
GOLDHABE 67 PRL 19  972        G.GOLDHABER,FIRESTONE,SHEN             (LRL)

ADERHOLZ 68 NP B 5  567        +DEUTSCHMANN+  (AACH+BERL+CERN+I.C.+VIENNA)
    ALSO 66 PL 22 357          BARTSCH,DEUTSCHMANN,MORRISON+    (ABCL(IC)V)
ANTICH   68 PRL 21 1842       +CALLAHAN,CARSON,COX,DENEGRI,+         (JHOP)
DUBAL    68 THESIS   1456      L.DUBAL                             (GENEVE)
KANG     68 PR 176 1587        Y.W.KANG                              (IOWA)
SCHWEING 68 PR 166 1317        SCHWEINGRUBER,DERRICK,FIELDS,AMMAR+(ANL+NW)
   ALSO  67  THESIS            F.L.SCHWEINGRUBER   (NORTHWESTERN,EVANSTON)

BASSOMPI 69 NP  B13 189        BASSOMPIERE,GOLDSCHMIDT-CLERM.+(CERN+BRUX)  JP
BISHOP   69 NP B 9 403         +GOSHAW,ERWIN,WALKER                  (WISC)
CRENNELL 69 PRL 22  487        +KARSHON,LAI,ONEALL,SCARR              (BNL)
DAVIS    69 PRL 23 1071        +DERENZO,FLATTE,ALSTON,LYNCH,SOLMITZ  (LRL)
DE BAERE 69 NC 61 A 397        +GOLDSCHMIDT-CLERMONT,HENRI,+   (BELG+CERN)
     SUPERSEDED BY BASSOMPIERRE 69
FRIEDMAN 69  UCRL-18860        J.FRIEDMAN,PH.D. THESIS                (LRL)
LIND     69  UCRL 19284        +ALEXANDER,FIRESTONE,FU,GOLDHABER      (LRL) JP
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$K_N(1660)$

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27  KN (1660, JP=  )  I = 1/2

EVIDENCE NOT COMPELLING, OMITTED FROM TABLE
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                  27  KN (1660) MASS  (MEV)

M        (1660.0)                     CARMONY   67 HBC   -  3.8 K-P,OMEGA K 11/67
M         1660.0     10.0             JOBES     67 HBC  +   5. K+ P          11/67
M   J     CLAIMED BY  JOBES IN (K PI), (K*(890) PI), AND (K*(1420) PI)
M   J     MODES. JOBES 67 SEES THE K PI BUMP MOSTLY IN  INTERFERENCE
M   J                                                   WITH N*(1236).

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                  27  KN (1660) WIDTH (MEV)

W            60.0      20.0           JOBES     67 HBC  +   5. K+ P          11/67

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                  27  KN (1660) PARTIAL DECAY MODES

                                                          DECAY MASSES
P1     KN*(1660) INTO K PI                                493+ 139
P2     KN*(1660) INTO K PI PI                             493+ 139+ 139
P3     KN*(1660) INTO K*(890) PI                          892+ 139
P4     KN*(1660) INTO K*N(1420) PI                       1409+ 139

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                       REFERENCES FOR KN(1660)

CARMONY  67 PRL  18  615      D.CARMONY,T.HENDRICKS,L.LANDER   (LA JOLLA)
JOBES    67 PL 26B 49         +BASSOMPIERRE,DE BAERE +   (BIRM+CERN+BRUX)
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$K_A(1775)$ or L

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23    KA (1775, JP=  )  I = 1/2
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Note for the $K^*(1775)$ Meson

This $K\pi\pi$ bump was named L by BARTSCH 68, who reported a peak with Γ = 127 MeV and several decay modes. In a much larger experiment, however, BARBARO-GALTIERI 69 find only a very broad peak (300-500 MeV), and only in the mode $K^*(1420)\pi$. Moreover, they show in Fig. 2 of their paper that there is a broad $K\pi\pi$ bump associated with any $K\pi$ mass selection. Thus if $K\pi$ mass is selected at the $K^*(892)$ one finds a broad $K\pi\pi$ peak in the "Q region," if the $K\pi$ mass is selected at the $K^*(1420)$ one finds the "L," if the $K\pi$ mass is selected in between, one still finds a 300-500 MeV threshold peak.

Data in parentheses have not been included in our averages.

The contradictions are now summarized:

	BARTSCH 68	BARBARO-GALTIERI 69
Beam:	10-GeV/c K^-	12-GeV/c K^+
Events above background:	60	60
Γ (MeV):	127±43	400±100
$K^*(1420)\pi/K\pi\pi$:	(19±15)%	100%
Interpretation:	Resonance	$K^*(1420)\pi$ threshold
J^P:	$1^+, 2^-, 3^+, \cdots$	$2^+ \cdot 0^- = 2^-$

Until these discrepancies are resolved, the resonant interpretation of the L peak must be subject to the same reservations as apply to the other threshold enhancements (Q region in $K\pi\pi$, A_1 region in $\rho\pi$, etc.). Even if there is a narrower peak in the data of BARTSCH 68, at least some of the peak must be this $K^*(1420)\pi$ enhancement. Background subtraction is then hazardous, and we have chosen not to quote any branching ratios.

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                     23   KA (1775) MASS (MEV)

M       20(1780.)                       BERLINGHI 67 HBC  +   12.7 K+P       7/67
M          1760.0      15.0             JOBES     67 HBC  +   5. K+ P       11/67
M          1785.0      12.0             BARTSCH   68 HBC      10.0 K- P      9/69*
M          . . . . . . . . .
M   AVG    1775.2      12.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
------ --------- --------- --------- --------- --------- --------- --------
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```
                     23   KA (1775) WIDTH (MEV)

W      20  (80.)                       BERLINGHI 67 HBC  +   12.7 K+P       7/67
W           60.0      20.0             JOBES     67 HBC  +   5. K+ P       11/67
W          127.0      43.0             BARTSCH   68 HBC      10.0 K- P      9/69*
W          . . . . . . . . .
W   AVG     71.9      25.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
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                     23   KA (1775) PARTIAL DECAY MODES

                                                            DECAY MASSES
P1     KA   INTO K PI                                      497+ 134
P2     KA   INTO K RHO                                     497+ 765
P3     KA   INTO K*(890) PI                                134+ 892
P4     KA   INTO K OMEGA                                   497+ 783
P5     KA   INTO K PI PI                                   497+ 134+ 134
P6     KA   INTO K*(1420) PI                               134+1409
P7     KA   INTO K ETA                                     497+ 548
P8     KA   INTO K PHI                                     497+1019
P9     KA   INTO K*(890) ETA                               548+ 892
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                     23   KA (1775) BRANCHING RATIOS

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                        REFERENCES FOR KA(1775)

BERLINGH 67 PRL 18 1087       BERLINGHIERI+FARBER+FERBEL+FORMAN+    (ROCH)I
JOBES    67 PL 26B 49         +BASSOMPIERRE,DE BAERE +    (BIRM+CERN+BRUX)
DENEGRI  68 PRL 20 1194       +CALLAHAN+ETTLINGER+GILLESPIE+    (JOHNSHOP)
BARTSCH  68 NP B8 9           +COCCONI,+          (AACH+BERL+CERN+LOIC+IHAW)

ANDREWS  69 PRL 22 731        +LACH,LUDLAM,SANDWEISS,BERGER,+  (YALE+LRL)
BARBARO1 69 PRL 22 1207       BARBARO-GALTIERI,DAVIS,FLATTE,+        (LRL)
BARBARO2 69  LUND PAPER 89    SAME AUTHORS AS ABOVE - DATA DOUBLED  (LRL)
COLLEY   69 NC A 59 519       +EASTWOOD,+  (BIRM+GLAS+LOIC+MPIM+OXF+RHEL)

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K*(2240)

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40  K* (2240, JP=  )  I=1/2

 ENHANCEMENT SEEN IN (ANTIHYPERON+NUCLEON) MASS.
 EVIDENCE NOT COMPELLING, OMITTED FROM TABLE.
------ --------- --------- --------- --------- --------- --------- --------

                     40   K* (2240)  MASS (MEV)

M      15 2240.      20.           ALEXANDER 68 HBC  + 0 9 K+P,YBAR+N+..  6/68
------ --------- --------- --------- --------- --------- --------- --------

                     40   K* (2240)  WIDTH (MEV)

W      15.  70.      20.           ALEXANDER 68 HBC  + 0 9 K+P,YBAR+N+..  6/68
****** ********* ********* ********* ********* ********* ********* ********

                        REFERENCES FOR K*(2240)

ALEXANDE 68 PRL 20 755        ALEXANDER,FIRESTONE,GOLDHABER,SHEN    (LRL)

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See the illustrated key preceding the data card listings.

Note on N's and Δ's

There are now complete phase-shift analyses from four different groups: The Saclay group (referred to as BAREYRE 68), the Berkeley group (JOHNSON 67), the Glasgow group (DAVIES 68), and the CERN group.

The CERN group has performed two phase-shift analyses, using different methods. The CERN I solution is published as DONNACHIE-1 68 for both Ispin 1/2 and 3/2. Their figures contain two sorts of results:
1. "Experimental Phase Shifts," i.e., partial-wave amplitudes at each energy at which they used experimental input. These are plotted as η and δ at each energy, but not as Argand plots.
2. "Theoretical Fits" using smooth functions based on dispersion-relation theory. These are plotted both as smooth curves of η and δ vs energy, and as Argand plots.
Brody et al.[1] have recently criticized the "Theoretical Fits" because it turns out that although the "experimental" amplitudes describe the data as well as (or better than) any other available set, the theoretical fits for some rapidly varying partial waves are too smooth. Because they are so convenient to draw and to remember, we continue to present these smooth Argand plots, having warned the reader of their limitations.

The newer solution, CERN II,[2] covers I = 3/2 only, and has been published only as Argand plots of "experimental" amplitudes.

We reproduce here, in Figs. 1, 2, 3, most of the available Argand diagrams. The Berkeley diagrams, from which the authors do not yet quote resonance parameters, are reproduced here only for I = 1/2 partial waves.[3] Table I is a summary of all the states claimed by the various groups with our evaluation of their significance. We have included in the Baryon Table only states listed as "good" or "fair."

Spread Among Resonance Parameters

Values of masses, widths, and branching ratios can be obtained only from phase-shift analyses. In production experiments, in fact, it is seldom clear which of the many states at similar masses is being observed. We now have complete phase-shift analyses from four different groups, but we are quite far from having reliable masses and widths derived therefrom.

The problem is that the errors on the phase shifts are quite large and it is thus difficult to draw smooth curves on the Argand diagrams. In addition, except for the Glasgow solutions, where an energy-dependent fit to the data and phase shifts is done, the resonance parameters are just the result of an "eyeball" fit with the use of different methods. As a result, different authors using the same phase shifts often estimate different values of M, Γ, x. This is the case for the CERN I solution, from which three sets of parameters have been reported. The Glasgow analysis actually gives two solutions and the Saclay analysis gives two sets of parameters depending on the method used. In order to make the reader aware of this problem we report here a table, Table II, with all the different values for M, Γ, x. On the main table of Baryon Resonances we decided not to quote a value with an error, but to quote a range of masses and widths in order to point out the large indeterminancy of these parameters. So the P'_{11} will be M = 1435 to 1505 MeV, Γ = 200 to 400 MeV, etc.

Footnotes and References

1. A. D. Brody, D. W. G. S. Leith, B. G. Levi, B. C. Shen, D. Herndon, R. Longacre, L. Price, A. H. Rosenfeld, and P. Söding, Phys. Rev. Letters 22, 1401 (1969).
2. The CERN II Argand plots have been reported by A. Donnachie, 14th International Conference on High Energy Physics, Vienna, 1968, p. 139.
3. For the complete set of Argand plots including speed versus energy, see UCRL-8030 Part II by D. J. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld.

Table I. Our evaluation of the status of all N and Δ resonances as seen in partial-wave analyses. D = definite, Pr = probable, Po = possible, A = ambiguous, No = not present. Notice that in the Glasgow fits the resonance hypothesis is built into the fit, so only the symbols D or No apply, except for one Pr at the upper end.

	Berkeley	CERN I	Saclay	Glasgow	RBD[a]	CERN II	Our evaluation	ηn	KΛ	KΣ	πΔ	ρN	γN
$P'_{11}(1470)$	D	D	D	D			Good						
$D'_{13}(1520)$	D	D	D	D			Good				D		D
$S'_{11}(1535)$	D	D	D	D			Good	D					D
$D''_{13}(1700)$	Po	Po	Po	No			Poor						
$D_{15}(1670)$	D	D	D	D			Good				Pr[b]		
$F_{15}(1688)$	D	D	D	D			Good				Pr[b]		D
$S''_{11}(1700)$	D	D	D	D			Good	Po	D				
$P''_{11}(1780)$	Pr	Pr	Pr	D			Fair	Po	D				
$P'_{13}(1860)$	A[c]	A	A[c]	Pr	Pr		Fair						
$F_{17}(1990)$	c	Pr	c	e	D		Fair						
$D'''_{13}(2040)$	c	Pr	c	c	D		Fair						
$G_{17}(2190)$	c	D	c	c	Pr		Fair						
$P'_{33}(1236)$							Good						D
$S''_{31}(1650)$	D	D	D	D		D	Good				Po[b]		
$P''_{33}(1690)$	Po	A	A	No		A	Poor				Po[b]		
$D_{33}(1670)$	A	D	Po	D		D	Fair				Po[b]		
$F_{35}(1890)$	Pr	Pr	Po	D		Pr	Fair						
$P_{31}(1910)$	Pr[c]	Pr	A[c]	D		D	Fair						
$D_{35}(1960)$	c	A	A[c]	c	Po	A	Poor						
$F_{37}(1950)$	D	D	D	D		D	Good			Pr[b]	D	D	D
$P'''_{33}(2160)$	Po[c]	Po	c	c		d	Poor						

[a]RBD = LEA 69 (Lea et al., Ruth, Bristol, Daresbury).

[b]For these references see DONNACHIE-2, the latter part of the article.

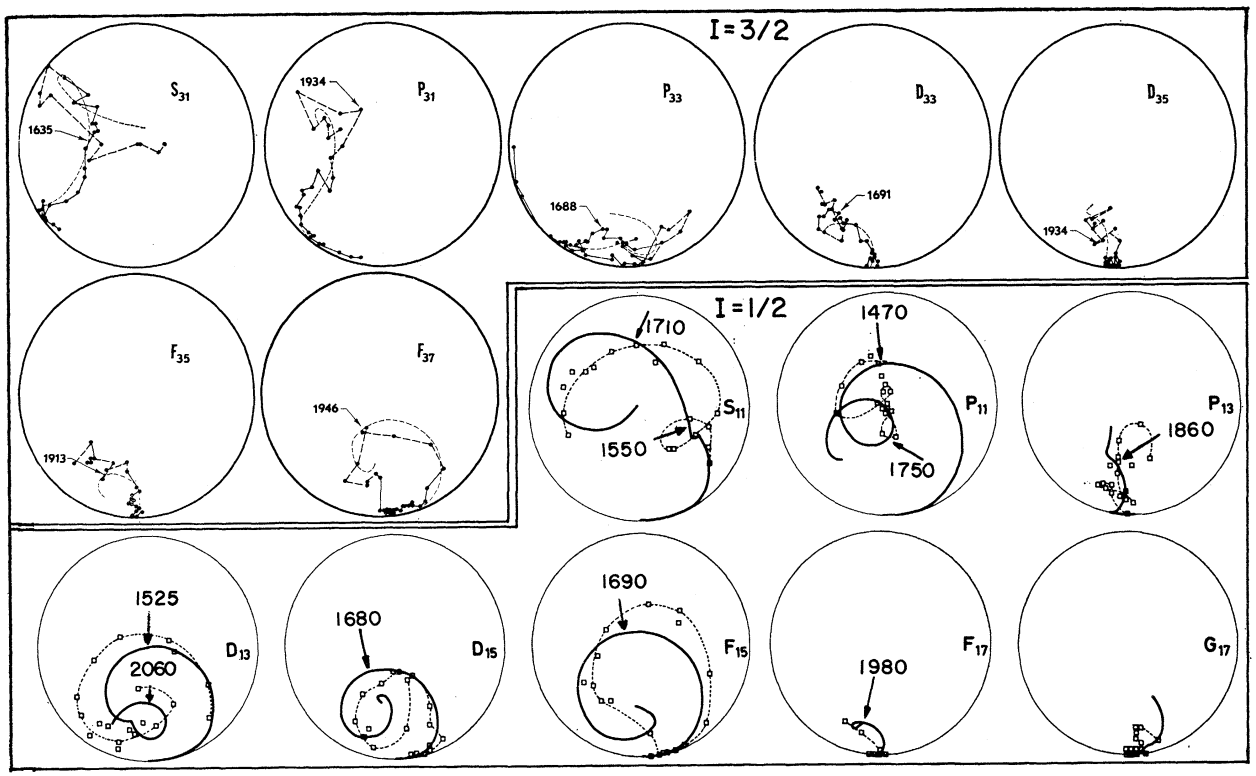
[c]This state is very close to or beyond their highest energy.

[d]We can't say anything.

[e]Glasgow A has a G_{17} state, Glasgow B may have an F_{17}. However, this region is very close to their highest energy.

PARTIAL-WAVE AMPLITUDES FOR CERN I, CERN II, AND BERKELEY SOLUTIONS.

(Arrows point to approximate resonance positions.)



XBL 6712-5862

Fig. 1. Results of the phase-shift analyses of the CERN and Berkeley groups. The CERN I results are the smooth curves (dashed in the I = 3/2 diagrams). This analysis used dispersion relations to join and smooth the solutions found at different energies. The arrows in the I = 1/2 diagrams indicate approximate resonance positions; they have been drawn by us. The CERN II solution is shown (as a dot-dash line) only for the I = 3/2 amplitudes since the I = 1/2 are not available. The arrows have been drawn by the authors. The Berkeley solution is shown only for the I = 1/2 state (as empty squares joined by dashes).

BARYON RESONANCES

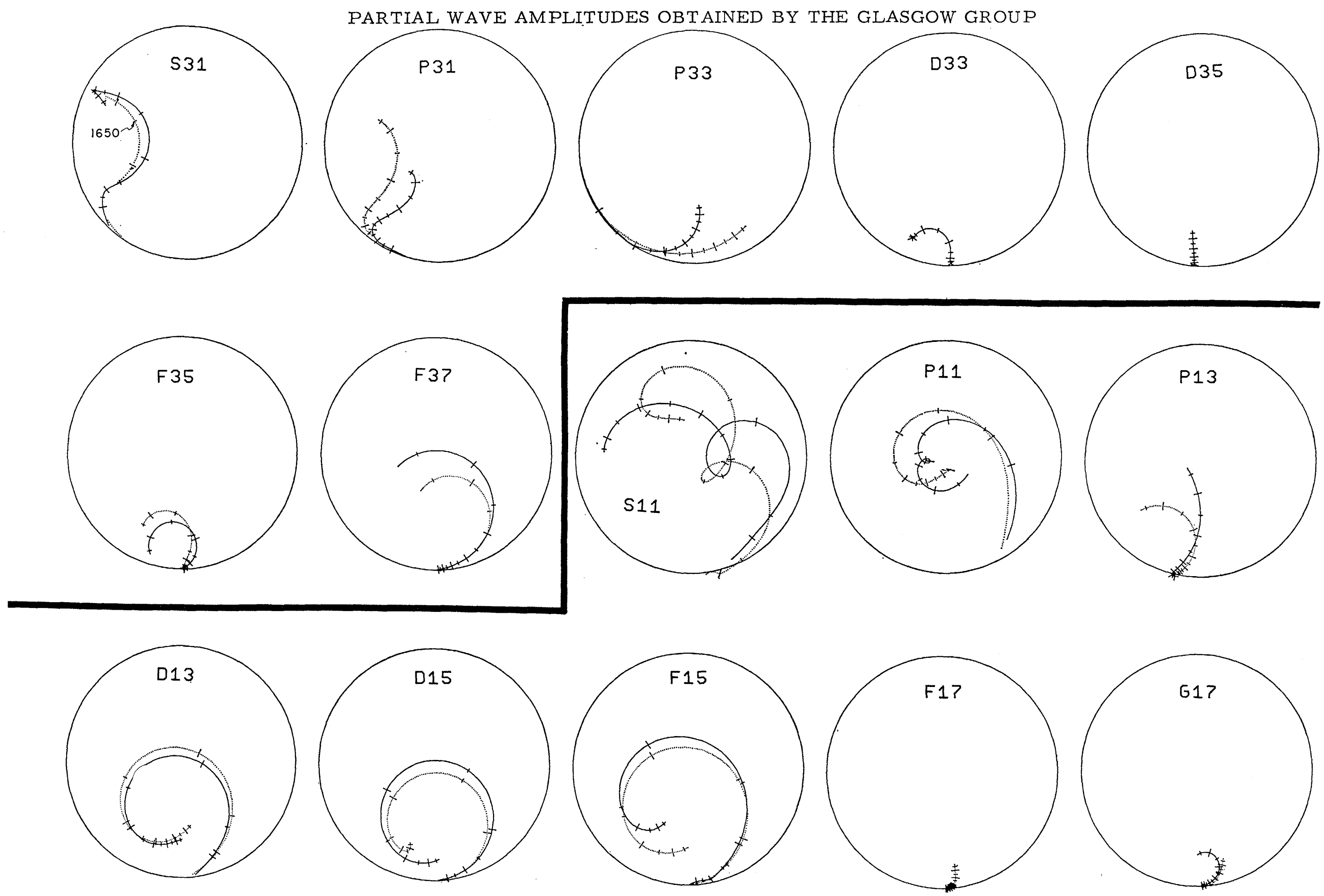


Fig. 2. Partial wave analysis results of DAVIES 68. The curves plotted here are the results of the energy-dependent analysis. DAVIES A (solid curves) is obtained by starting from the set of phase shifts best solution of the Glasgow group. DAVIES B (dashed curves) is obtained by starting from the CERN 1 phase shifts. DAVIES B is not shown when it is very close to DAVIES A. Scale marks are shown every 50 MeV. The first large mark is at M = 1400 MeV, the last large mark at M = 1900 MeV.

PARTIAL WAVE AMPLITUDES OBTAINED BY THE SACLAY PHASE SHIFT ANALYSIS (BAREYRE et al)

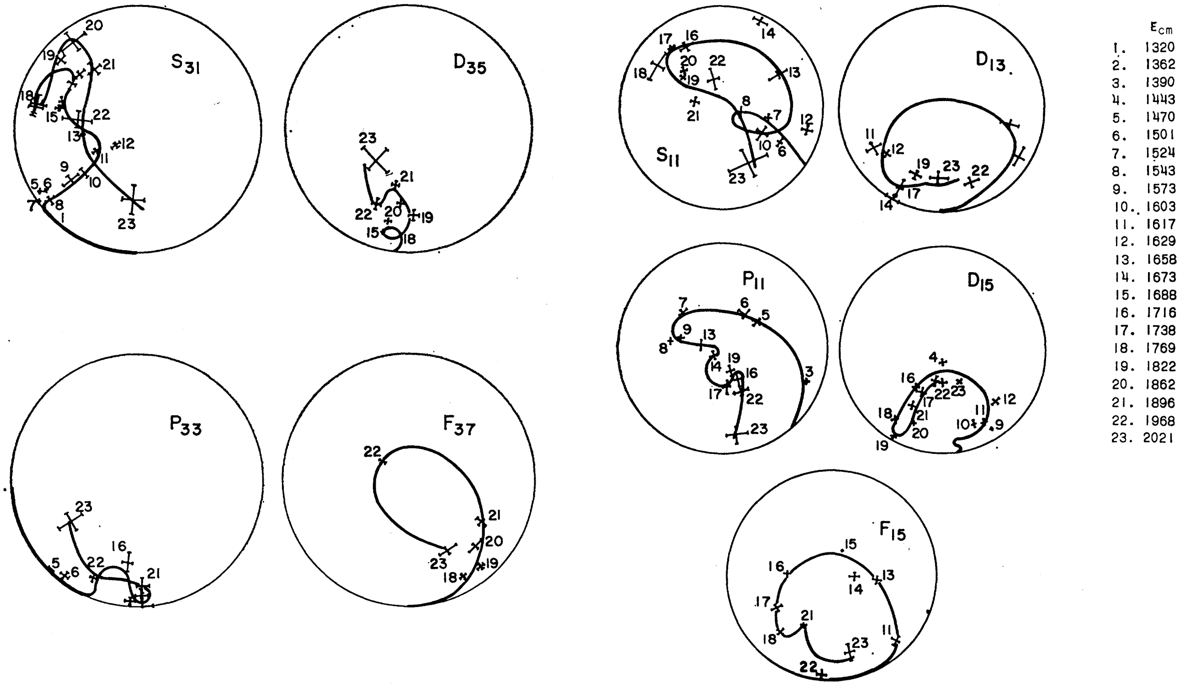


Fig. 3. Saclay πp phase-shift analysis.

Table II. Resonance parameters for N^* and Δ from phase-shift analyses, as listed by their authors. The $P_{33}(1236)$ is not included because the analyses listed start at higher energy. BAREYRE 68 uses two methods to find resonance parameters: 1—(σ) the energy where the total cross section is maximum, 2—(speed) the energy where the speed of variation of the amplitude in the Argand plot is maximum. CERN quotes only one method, usually where the absorption is maximum, but three different sets of values have been given. The Glasgow group (DAVIES 68) uses Breit-Wigner parameterization; A and B differ in the starting values of the minimization (CERN I solution was used for solution B). For some states no parameters have been quoted by the authors. We report in the M column our evaluation of the status of this resonance as judged on the published Argand plots. Symbols are the same as on Table I.

The "Ind. Ext. Error" written below the average is the "external error" of the individual values, i.e., $\langle \delta x_i \rangle = \sqrt{\frac{1}{N} \sum_i (x_i - \bar{x})^2}$. The error $\bar{x}$ of the mean is of course smaller by another factor $1/\sqrt{N}$ but we avoid giving it because we feel that $\bar{x}$, $\delta\bar{x}$ have little meaning here.

Table II. (see caption on preceding page)

I = 1/2 States

• P'_{11} (1470)

			Method	M	Γ	x
1	Bareyre	68	σ	1470	255	0.68
2	Bareyre	68	Speed	1505	205	0.68
3	Berkeley	67		D		
4	Donnachie-1	68	Abs.	1466	211	0.658
5	Donnachie-2	68	Abs.	1470	211	0.66
6	Kirsopp	68	Abs.	1466	211	0.66
7	Glasgow	68	A	1462	391	0.49
8	Glasgow	68	B	1436	224	0.46
Average				1468	244	0.61
± Ind. ext. error				±19	±62	±.09

• D'_{13} (1520)

			Method	M	Γ	x
1	Bareyre	68	σ	1510	125	0.54
2	Bareyre	68	Speed	1515	110	0.54
3	Berkeley	67		1526[a]	114[a]	0.57[a]
4	Donnachie-1	68	Abs.	1541	149	0.509
5	Donnachie-2	68	Abs.	1520	114	0.57
6	Kirsopp	68	Abs.	1526	115	0.57
7	Glasgow	68	A	1512	106	0.45
8	Glasgow	68	B	1512	125	0.49
Average				1520	120	0.53
± Ind. ext. error				±10	±13	±.04

• S'_{11} (1535)

			Method	M	Γ	x
1	Bareyre	68	σ	1535	155	—
2	Bareyre	68	Speed	1515	105	—
3	Berkeley	67		1548[a]	116[a]	0.326[a]
4	Donnachie-1	68	Abs.	1591	(268)	0.696
5	Donnachie-2	68	Abs.	1550	116	0.33
6	Kirsopp	68	Abs.	1540	160	0.3
7	Glasgow	68	A	1502	(36)	0.36
8	Glasgow	68	B	1499	53	0.35
Average				1535	118	0.39
± Ind. ext. error				±28	±35	±.14

• D''_{13} (1700)

			Method	M	Γ	x
1	Bareyre	68	σ			
2	Bareyre	68	Speed	Po		
3	Berkeley	67		Po		
4	Donnachie-1	68	Abs.	—	—	—
5	Donnachie-2	68	Abs.	1730		
6	Kirsopp	68	Abs.	1680		
7	Glasgow	68	A	No		
8	Glasgow	68	B	No		
Average				1705		
± Ind. ext. error				±25		

• D_{15} (1670)

			Method	M	Γ	x
1	Bareyre	68	σ	1680	135	0.41
2	Bareyre	68	Speed	1655	105	0.41
3	Berkeley	67		D		
4	Donnachie-1	68	Abs.	1678	173	0.391
5	Donnachie-2	68	Abs.	1680	173	0.391
6	Kirsopp	68	Abs.	1678	175	0.391
7	Glasgow	68	A	1669	115	0.50
8	Glasgow	68	B	1667	115	0.43
Average				1672	142	0.42
± Ind. ext. error				±10	±29	±.04

• F_{15} (1688)

			Method	M	Γ	x
1	Bareyre	68	σ	1690	110	0.64
2	Bareyre	68	Speed	1680	105	0.64
3	Berkeley	67		1692[a]	132[a]	0.68[a]
4	Donnachie-1	68	Abs.	1687	177	0.56
5	Donnachie-2	68	Abs.	1690	132	0.68
6	Kirsopp	68	Abs.	1692	130	0.68
7	Glasgow	68	A	1685	104	0.54
8	Glasgow	68	B	1684	123	0.54
Average				1688	127	0.62
± Ind. ext. error				±4	±22	±.06

• S''_{11} (1700)

			Method	M	Γ	x
1	Bareyre	68	σ	1710	260	—
2	Bareyre	68	Speed	1665	110	—
3	Berkeley	67		1709[a]	300[a]	0.786[a]
4	Donnachie-1	68	Abs.	—	—	—
5	Donnachie-2	68	Abs.	1710	300	0.79
6	Kirsopp	68	Abs.	1709	300	0.79
7	Glasgow	68	A	1766	404	0.56
8	Glasgow	68	B	1671	121	0.51
Average				1706	256	0.69
± Ind. ext. error				±31	±98	±.13

• P''_{11} (1780)

			Method	M	Γ	x
1	Bareyre	68	σ	Pr		
2	Bareyre	68	Speed	Pr		
3	Berkeley	67		Pr		
4	Donnachie-1	68	Abs.	1751	327	0.32
5	Donnachie-2	68	Abs.	1750	327	0.32
6	Kirsopp	68	Abs.	1860	270	0.32
7	Glasgow	68	A	1770	445	0.43
8	Glasgow	68	B	(1867)	(525)	0.30
Average				1783	350	0.34
± Ind. ext. error				±45	±63	±.05

• P'_{13} (1860)

			Method	M	Γ	x
1	Bareyre	68	σ	A[b]		
2	Bareyre	68	Speed	A[b]		
3	Berkeley	67		A[b]		
4	Donnachie-1	68	Abs.	1863	296	0.207
5	Donnachie-2	68	Abs.	1860	296	0.21
6	Kirsopp	68	Abs.	1900	325	0.25
7	Glasgow	68	A	1844	449	0.40
8	Glasgow	68	B	1854	307	0.26
9	Lea	69		1860	—	—
Average				1864	335	0.27
± Ind. ext. error				±17	±58	±.07

• F_{17} (1990)

			Method	M	Γ	x
1	Bareyre	68	σ	b		
2	Bareyre	68	Speed	b		
3	Berkeley	67		b		
4	Donnachie-1	68	Abs.	1983	225	0.128
5	Donnachie-2	68	Abs.	—	—	—
6	Kirsopp	68	Abs.	1995	250	0.09
7	Glasgow	68	A	c		
8	Glasgow	68	B	c		
9	Lea	69		~2000	—	—
Average				1989	238	0.109
± Ind. ext. error				±6	±12	±.019

• D'''_{13} (2040)

			Method	M	Γ	x
1	Bareyre	68	σ	b		
2	Bareyre	68	Speed	b		
3	Berkeley	67		b		
4	Donnachie-1	68	Abs.	2057	293	0.26
5	Donnachie-2	68	Abs.	2030	290	0.11
6	Kirsopp	68	Abs.	2040	240	0.15
7	Glasgow	68	A	b		
8	Glasgow	68	B	b		
9	Lea	69		2030	—	—
Average				2039	274	0.17
± Ind. ext. error				±11	±24	±.06

• G_{17} (2190)

			Method	M	Γ	x
1	Bareyre	68	σ	b		
2	Bareyre	68	Speed	b		
3	Berkeley	67		b		
4	Donnachie-1	68	Abs.	2265	298	0.349
5	Donnachie-2	68	Abs.	2190	300	0.35
6	Kirsopp	68	Abs.	2265	300	0.35
7	Glasgow	68	A	(1906)[c]	(319)[c]	(0.14)[c]
8	Glasgow	68	B	c		
9	Lea	69		~2000		
Average				2180	299	0.350
± Ind. ext. error				±35	±2	±.001

I = 3/2 States

• S_{31} (1650)

			Method	M	Γ	x
1	Bareyre	68	σ	1695	250	—
2	Bareyre	68	Speed	1650	130	—
3	Berkeley	67		D		
4	Donnachie-1	68	Abs.	1635	177	0.284
5	Donnachie-2	68	Abs.	1640	177	0.28
6	Kirsopp	68	Abs.	1635	180	0.28
7	Glasgow	68	A	1670	141	0.28
8	Glasgow	68	B	1623	140	0.25
Average				1650	151	0.27
± Ind. ext. error				±23	±89	±.12

• P''_{33} (1690)

			Method	M	Γ	x
1	Bareyre	68	σ	A		
2	Bareyre	68	Speed	A		
3	Berkeley	67		Po		
4	Donnachie-1	68	Abs.	1688	281	0.098
5	Donnachie-2	68	Abs.	1690	281	0.1
6	Kirsopp	68	Abs.	1690	240	0.08
7	Glasgow	68	A	No		
8	Glasgow	68	B	No		
Average				1689	267	0.93
±Ind. Ext. Error				±2	±19	±0.09

• D_{33} (1670)

			Method	M	Γ	x
1	Bareyre	68	σ	Po		
2	Bareyre	68	Speed	Po		
3	Berkeley	67		A		
4	Donnachie-1	68	Abs.	1691	269	0.14
5	Donnachie-2	68	Abs.	1690	269	0.14
6	Kirsopp	68	Abs.	1690	300	0.13
7	Glasgow	68	A	1649	188	0.12
8	Glasgow	68	B	1650	174	0.13
Average				1674	240	0.13
± Ind. ext. error				±20	±50	±.01

• F_{35} (1890)

			Method	M	Γ	x
1	Bareyre	68	σ	Po		
2	Bareyre	68	Speed	Po		
3	Berkeley	67		Pr		
4	Donnachie-1	68	Abs.	1913	350	0.16
5	Donnachie-2	68	Abs.	1910	350	0.16
6	Kirsopp	68	Abs.	1910	380	0.15
7	Glasgow	68	A	1841	136	0.2
8	Glasgow	68	B	1852	150	0.19
Average				1885	273	0.17
± Ind. ext. error				±32	±107	±.02

• P_{31} (1910)

			Method	M	Γ	x
1	Bareyre	68	σ	A[b]		
2	Bareyre	68	Speed	A[b]		
3	Berkeley	67		Pr[b]		
4	Donnachie-1	68	Abs.	1934	339	0.30
5	Donnachie-2	68	Abs.	1930	339	0.3
6	Kirsopp	68	Abs.	1930	425	0.25
7	Glasgow	68	A	1914	290	0.18
8	Glasgow	68	B	1834	231	0.24
Average				1908	325	0.25
± Ind. ext. error				±38	±64	±.04

• D_{35} (1960)

			Method	M	Γ	x
1	Bareyre	68	σ	A[b]		
2	Bareyre	68	Speed	A[b]		
3	Berkeley	67		b		
4	Donnachie-1	68	Abs.	1954	311	0.154
5	Donnachie-2	68	Abs.	—	—	—
6	Kirsopp	68	Abs.	1970	400	0.12
7	Glasgow	68	A	b		
8	Glasgow	68	B	b		
9	Lea	69		1950	—	—
Average				1958	356	0.14
± Ind. ext. error				±9	±44	±.02

• F_{37} (1950)

			Method	M	Γ	x
1	Bareyre	68	σ	1975	180	0.57
2	Bareyre	68	Speed	1980	140	—
3	Berkeley	67		D		
4	Donnachie-1	68	Abs.	1946	221	0.386
5	Donnachie-2	68	Abs.	1950	221	0.39
6	Kirsopp	68	Abs.	1946	220	0.39
7	Glasgow	68	A	1935	221	0.51
8	Glasgow	68	B	1935	212	0.39
Average				1952	202	0.44
± Ind. ext. error				±19	±29	±.07

• P'''_{33} (2160)

			Method	M	Γ	x
1	Bareyre	68	σ	b		
2	Bareyre	68	Speed	b		
3	Berkeley	67		Po[b]		
4	Donnachie-1	68	Abs.			
5	Donnachie-2	68	Abs.			
6	Kirsopp	68	Abs.	2160	260	0.25
7	Glasgow	68	A	b		
8	Glasgow	68	B	b		
Average				2160	260	0.25
± Ind. ext. error				—	—	—

( ) Values in parentheses have not been used in the averages.

[a] Values quoted by Lovelace, rapporteur talk at Heidelberg Conference (1967), p. 109.

[b] This state is very close to or beyond their highest energy.

[c] Glasgow A has a G_{17} state at this mass, Glasgow B may have an F_{17} and a G_{17}; however, this energy region is very close to their highest energy.

Data in parentheses have not been included in our averages.

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CODE EVENTS QUANTITY  ERROR+  ERROR-  REFERENCE YR TECN SIGN COMMENTS  DATE
    ABOVE                                                          PUNCHED
  BACKGROUND

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p

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            16  PROTON  (938, J=1/2)  I=1/2

            SEE LISTINGS OF STABLE PARTICLES

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n

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            17  NEUTRON  (939, J=1/2)  I=1/2

            SEE LISTINGS OF STABLE PARTICLES

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N(1470) **P'11**

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            61  N*1/2(1470, JP=1/2+) I=1/2

            FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE
            PRECEDING N*3/2(1236).

   THE MASS AND WIDTH ARE BEST DETERMINED FROM PHASE-SHIFT ANALYSES.  WE
   LIST PRODUCTION EXPERIMENTS SEPARATELY--SEE BELOW.

----------------   61  N*1/2(1470) MASS (MEV)     -----------------------

M          (1380.0)                  ROPER     65 RVUE   PHASE-SHIFT ANAL  9/66
M          (1370.0)                  BRANDSEN  65 RVUE   PHASE-SHIFT ANAL  9/66
M    1     (1470.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2     (1505.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     2            WHERE SPEED IS GREATEST - EYEBALL FIT
M    4     (1462.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
M    5     (1436.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACHI 68)
M    3     (1466.0)                  DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M    3     (1470.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
M    3     (1466.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*

----------------   61  N*1/2(1470) WIDTH (MEV)    -----------------------

W    1      (255.0)                  BAREYRE   68 RVUE                    11/67
W    2      (205.0)                  BAREYRE   68 RVUE                    11/67
W    4      (391.)                   DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
W    5      (224.)                   DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
W    3      (211.0)                  DONNACH1  68 RVUE                     6/68
W    3      (211.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
W    3      (210.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------   61  N*1/2(1470) PARTIAL DECAY MODES    ---------------

                                                        DECAY MASSES
P1          N*1/2(1470) INTO PI N                      139+ 938
P2          N*1/2(1470) INTO N SIGMA (SIGMA MESON)     938+ 410
P3          N*1/2(1470) INTO N*3/2(1236) PI           1236+ 139
P4          N*1/2(1470) INTO N PI PI                   938+ 139+ 139

----------------   61  N*1/2(1470) BRANCHING RATIOS   -------------------

R1          N*1/2(1470) INTO (PI N)/TOTAL             (P1)/TOTAL
R1   1        (0.68)                 BAREYRE   68 RVUE                    11/67
R1   4        (0.49)                 DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
R1   5        (0.46)                 DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
R1   3        (0.658)                DONNACH1  68 RVUE                     6/68
R1   3         (.66)                 DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1   3         (.66)                 KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2          N*1/2(1470) INTO (N SIGMA)/TOTAL          (P2)/TOTAL
R2          DOMINANT INELASTIC DECAY   THURNAUER 65 RVUE  -               11/67
R2          DOMINANT INELASTIC DECAY   NAMYSLOWS 66 RVUE  -               11/67
R2          DOMINANT INELASTIC DECAY   ROSENFELD 67 RVUE  -               11/67
R2          DOMINANT INELASTIC DECAY   MORGAN    68 RVUE   ISOBAR MODEL    6/68

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                        REFERENCES -- N*1/2(1470)
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ROPER    65 PR 138 B190        LD ROPER,RM WRIGHT,BT FELD   (LRL-LVMR,MIT)IJP
BRANDSEN 65 PR 139 B1566       +ODONNELL, MOORHOUSE         (DURHAM,RTHFD)IJP
THURNAUE 65 PRL 14 985         P G THURNAUER                           (ROCH)
NAMYSLOW 66 PR 157 1328        NAMYSLOWSKI,RAZMI,ROBERTS   (STAN,EDINB,IC)
ROSENFEL 67 IRVINE CONF        A H ROSENFELD, P SODING                  (LRL)

BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DAVIES   68 VIENNA CONF        A DAVIES,R MOORHOUSE                    (GLAS)
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
KIRSOPP  68 THESIS             R G KIRSOPP                             (EDIN)
MORGAN   68 PR 166 1731        D MORGAN                               (RTHFD)

                 PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE  64 PL 8 137           +BRICMAN,VALLADAS,VILLET, +   (SACLAY,CAEN) IJ
BAREYRE  65 PL 18 342          +BRICMAN, STIRLING, VILLET         (SACLAY)IJP
DALITZ   65 PL 14 159          R H DALITZ, R G MOORHOUSE         (OXF,RTHFD)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
      THE FOLLOWING ARE THEORETICAL PAPERS CONCERNING THE N*1/2(1470) --
RESNICK  66 PR 150 1292        L RESNICK                         (NIELS BOHR)
SCHWARZ  66 PR 152 1325        J H SCHWARZ                              (LRL)
BALL     67 PR 155 1725        JS BALL, GL SHAW, DY WONG   (UCLA,UCI,UCSD)
GOLDBERG 67 PR 154 1558        H GOLDBERG                           (CORNELL)
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1470 MEV REGION - PRODUCTION EXPERIMENTS

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                   61 N*(1470)    PROD. EXP.

                IT IS NOT CLEAR THAT THE BUMP SEEN IN PRODUCTION EXPE-
                RIMENTS AT LOW INVARIANT MASS CORRESPONDS TO THE P11
                RESONANT STATE.  DIFFRACTION SCATTERING SEEMS TO BE THE
                DOMINANT FEATURE IN THIS MASS REGION- SEE GELLERT 66,
                WALKER 68 AND CLEGG 68 FOR DISCUSSION OF THIS POINT.
         WE LIST VALUES OF MASSES AND WIDTHS FROM THESE EXPERIMENTS FOR
         THE READER.S CONVENIENCE- THE LIST MAY NOT BE COMPLETE.
         THE CNTR AND SPRK EXPERIMENTS SEE A BUMP IN THE MISSING MASS
         PLOT. THE HBC EXPERIMENTS SEE A BUMP IN THE PPPI MASS PLOT. TAN
         68, SHAPIRA 68 SEE A BUMP IN PI P - PRODUCTION OF THIS STATE
         IN GAMMA-P OR GAMMA-D IS VERY SMALL, SEE ALBERI 68.

---------------     N*1/2(1470)  MASS (MEV)   PROD. EXPE. -----------------

M          (1425.)   APPROX             ADELMAN   65 HBC  +  K-P 1.45 GEV/C     7/66
M          (1400.)   APPROX             COCCONI   64 CNTR +  PP 3.6-12 GEV/C
M          (1430.)   APPROX             ANKENBRAN 65 CNTR +  PP 7.1 GEV/C       7/66
M          (1400.)   APPROX             BELLETTIN 65 SPRK +  PP,C 10-26 GEV/C   7/66
M          (1405.)    (15.)             ANDERSON  66 SPRK +  PP, 6-30 GEV/C     7/66
M          (1410.)    (15.)             BLAIR     66 CNTR +  PP 2.8-7.9 GEV/C   7/66
M          (1400.)    (30.)             FOLEY     67 CNTR    PI+- P AND PP     11/67

M          (1450.)    (17.)             ALMEIDA   68 HBC  +  PP-P2PI ,10GEV/C  10/69*
M          (1420.)   APPROX             BELL      68 HBC     PI+- P, 6 GEV/C    6/68
M       120(1443.)    (15.)             JESPERSEN 68 HBC     PP 22 GEV/C       10/69*
M          (1400.)   APPROX             LAMSA     68 HBC     PI-P , 8 GEV/C     6/68
M    S  175(1446.)    (11.)             SHAPIRA   68 DBC     INTO PPI,PN 7.0   10/69*
M    S   TAN 68, SHAPIRA 68 ARE ONLY PRODUCTION EXPERIMENT TO SEE PPI DECAY
M    S     (1390.)    (20.)             TAN       68 HBC     PP TO PIP, 6.1    10/69*

---------------     N*1/2(1470) WIDTH (MEV)   PROD. EXPE. -----------------

W           (100.)                      BELL      68 HBC     PI+- P AND PP      6/68
W       120 (100.)    (15.)             JESPERSEN 68 HBC     PP 22 GEV/C       10/69*
W    S  175 (198.)    (40.)             SHAPIRA   68 DBC                       10/69*
W    S      (150.)    (60.)             TAN       68 HBC  +                    10/69*

---------------     N*1/2(1470) BRANCHING RATIOS  PROD. EXP.  ------------

R1          N*1/2(1470) INTO (PI P)/TOTAL      PRODUC. EXPER.
R1            (.66)                     TAN       68 HBC     PP TO PIP, 6.1    10/69*

R2          N*1/2(1470) INTO (N*3/2(1236) PI)/TCTAL   PROD. EXP.
R2              PROBABLY SEEN           LAMSA     68 HBC     PI-P 8 BEV/C      11/68
R2              PROBABLY SEEN           JESPERSEN 68 HBC     PP 22 BEV/C       11/68

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                        REFERENCES -N*1/2(1470)-  PROD. EXP.
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COCCONI  64 PL   8 134        +LILLETHUN,SCANLON,STAHLBRANDT, +      (CERN)
ADELMAN  65 PRL 14 1043       S L ADELMAN                  (CAMBRIDGE(CERN))
ANKENBRA 65 NC  35 1052       ANKENBRANDT,CLYDE,CORK,KEEFE,KERTH+     (LRL)
BELLETTI 65 PL  18 167        BELLETTINI,COCCONI,DIDDENS +            (CERN)
ANDERSON 66 PRL 16  855       +BLESER,COLLINS,FUJII,+             (BNL,CARN)
BLAIR    66 PRL 17  789       +TAYLOR,CHAPMAN,+  (HARWELL,QUEENMARY,RHEL)
GELLERT  66 PRL 17 884        +SMITH,VOJCICKI,COLTON,SCHLEIN + (LRL,UCLA)

FOLEY    67 PRL 19  397       +JONES,LINDENBAUM,LOVE,OZAKI+            (BNL)
ALBERI   68 PR 176 1631       +APPEL,BUDNITZ,CHEN,DUNNING,GOITEIN+ (HARV)
ALMEIDA  68 PR 174 1638       +RUSHBROOKE,SCHARENGUIVEL+        (CAVE,DESY)
BELL     68 PRL 20  164       +CRENNELL,HOUGH,KARSHON,LAI+      (BNL,CCNY)
CLEGG    68  PREPRINT         A B CLEGG                               (LANC)

JESPERSE 68 PRL 21 1368       JESPERSEN,KANG,KERNAN, +         (IOWA STATE)
LAMSA    68 PR 166 1395       +CASON,BISWAS,DERADO,GROVES,+  (NOTRE DAME)
SHAPIRA  68 PRL 21 1835       +BENARY,EISENBERG,RONAT,YAFFE+          (REHO)
TAN      68 PL 28B 195         TAN,PERL,MARTIN,CHINOWSKY +  (SLAC+LRL+UCI)
WALKER   68 PRL 20 133        +THOMPSON,ROBERTSON,OH,LEE,HARTUNG,+ (WISC)
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                   END PRODUCTION EXPERIMENTS

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N(1520) **D'13**

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            62  N*1/2(1520, JP=3/2-) I=1/2

            FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
            PRECEDING N*3/2(1236).

----------------   62  N*1/2(1520) MASS (MEV)     -----------------------

M          (1536.0)                  ROPER     65 RVUE   PHASE-SHIFT ANAL  9/66
M          (1530.0)                  BRANDSEN  65 RVUE   PHASE-SHIFT ANAL  9/66
M    1     (1510.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2     (1515.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     2            WHERE SPEED IS GREATEST - EYEBALL FIT
M    3     (1541.0)                  DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M    3     (1520.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
M    3     (1526.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M    4     (1512.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
M    5     (1512.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------   62  N*1/2(1520) WIDTH (MEV)    -----------------------

W    1      (125.0)                  BAREYRE   68 RVUE                    11/67
W    2      (110.0)                  BAREYRE   68 RVUE                    11/67
W    3      (149.0)                  DONNACH1  68 RVUE                     6/68
W    3      (114.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
W    3      (115.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
W    4      (106.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A
W    5      (125.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------   62  N*1/2(1520) PARTIAL DECAY MODES    ---------------

                                                        DECAY MASSES
P1          N*1/2(1520) INTO PI N                      139+ 938
P2          N*1/2(1520) INTO N*3/2(1236) PI           1236+ 139
P3          N*1/2(1520) INTO N PI PI                   938+ 139+ 139
P4          N*1/2(1520)+ INTO NEUTRON PI+              939+ 139
P5          N*1/2(1520)+ INTO PROTON PI+ PI-           938+ 139+ 139
P6          N*1/2(1520) INTO N ETA                     939+ 548
P7          N*1/2(1520) INTO N SIGMA (SIGMA MESON)     939+ 410
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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-----------------   62  N*1/2(1520) BRANCHING RATIOS   ------------------

R1          N*1/2(1520) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1  1         (0.54)                 BAREYRE   68 RVUE                     11/67
R1  3         (0.509)                DONNACH1  68 RVUE                      6/68
R1  3          (.57)                 DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1  3          (.57)                 KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
R1  4         (0.45)                 DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
R1  5         (0.49)                 DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

     ALMOST THE ENTIRE INELASTICITY IS IN N PI PI (ONLY N ETA COULD COMPETE,
     AND IT DOESNT). THE N PI PI SEEMS TO BE MAINLY N*3/2(1236) PI, IN BOTH
     S AND D WAVES.

R2          N*1/2(1520) INTO (N*3/2(1236) PI)/TOTAL       (P4)/TOTAL
R2             DOMINANT INEL DECAY   OLSSON    66 RVUE    PI P TO PI PI N   9/66
R2             0.20      0.05        KIRZ      66 HBC  0  ASSUMING R1=0.72  9/66

R3          N*1/2(1520) INTO (N*3/2(1236) PI)/(N PI PI)   (P2)/(P3)
R3              LARGE                THURNAUER 65 RVUE -                   11/67
R3              LARGE                NAMYSLOWS 66 RVUE -                   11/67
R3              LARGE                ROBERTS   67 RVUE -                   11/67
R3              LARGE                ROSENFELD 67 RVUE -                   11/67
R3              LARGE                MORGAN    68 RVUE   ISOBAR MODEL       6/68

R4          N*1/2(1520) INTO (PI N)/(PI N*3/2(1236))      (P1)/(P2)
R4            (0.42)   OR LESS       LEE       67 ++C

R5          N*1/2(1520) INTO (N ETA)/TOTAL                (P6)/TOTAL
R5  D         (0.006)    APPROX      DAVIES    67 RVUE                     11/67
      DAVIES 67 GIVES SEVERAL VALUES DEPENDING ON INPUT DATA.  ALL ARE SMALL
R5            (0.014)                BOTKE     69 RVUE   T POLE+RES,FIT A 10/69*
R5            (0.003)  (0.001)       DEANS     69 RVUE   T POLE+RES ANAL   8/69*

R6          N*1/2(1520) INTO (N SIGMA)/TOTAL              (P7)/TOTAL
R6            PROBABLY PRESENT       MORGAN    68 RVUE   ISOBAR MODEL       6/68

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REFERENCES -- N*1/2(1520)

SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.


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BRANDSEN 65 PR 139 B1566      +ODONNELL, MOCRHOUSE          (DURHAM,RTHFD)IJP
ROPER    65 PR 138 B190       LD ROPER,RM WRIGHT,BT FELD    (LRL-LVMR,MIT)IJP
THURNAUE 65 PRL 14 985        P G THURNAUER                          (ROCH)
KIRZ     66 PRIVATE COMM      J KIRZ                                  (LRL)
      -- NUMBER EXTRACTED FROM DATA DISCUSSED IN KIRZ 63.
NAMYSLOW 66 PR 157 1328       NAMYSLOWSKI,RAZMI,ROBERTS     (STAN,EDINB,IC)
OLSSON   66 PR 145 1309       M G OLSSON, G B YODH               (WISC,MD)
DAVIES   67 NC 52A 1112       A T DAVIES, R G MOORHOUSE    (GLASGOW,RTHFD)
LEE      67 PR 159 1156       +MOEBS,ROE,SINCLAIR,VANDER VELDE       (MICH)
ROBERTS  67 PREPRINT          R G ROBERTS                          (DURHAM)
ROSENFEL 67 IRVINE CONF       A H ROSENFELD, P SODING                 (LRL)

BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET    (SACLAY)IJP
DAVIES   68 VIENNA CONF.      A DAVIES,R MOORHOUSE                   (GLAS)
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK           (GLAS)
KIRSOPP  68 THESIS            R G KIRSOPP                            (EDIN)
MORGAN   68 PR 166 1731       D MORGAN                              (RTHFD)
BOTKE    69 PR 180 1417       J C BOTKE                              (UCSB)
DEANS    69 PR 177 2623       S R DEANS                     (UNIV S FLORIDA)
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PAPERS NOT REFERRED TO IN DATA CARDS.

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KIRZ     63 PR 130 2481       J KIRZ, J SCHWARTZ, R D TRIPP           (LRL)
BAREYRE  65 PL 18 342         + BRICMAN, STIRLING, VILLET       (SACLAY)IJP
CROUCH   65 DESY CONF II 21   +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244   +KENNEY,LAMSA, +       (NOTRE DAME,KENTUCKY)
MERLO    66 P ROY SOC 289 489 J P MERLO, G VALLADAS                (SACLAY)
      -- THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE RESONANCE.
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)
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N(1535) — S'_{11}

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63  N*1/2(1535, JP=1/2-) I=1/2

FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

-------------------63  N*1/2(1535) MASS (MEV)   ------------------------

M           (1519.0)                 HENDRY    65 RVUE   ETA N + S11 PI N  9/66
M           (1570.0)                 MICHAEL   66 RVUE   FITS BAREYRE S11  7/66
M   N       (1557.0) OR  1565.0      UCHIYAMA- 66 RVUE   FITS N ETA DATA   9/66
M   N        FITTING GIVES TWO SOLUTIONS.  PROBLEMS MATCHING PI P PHASE SHIFT
M   1       (1535.0)                 BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
    1             WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M   2       (1515.0)                 BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
    2             WHERE SPEED IS GREATEST - EYEBALL FIT
M   3       (1591.0)                 DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M   3       (1550.)                  DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
M   3       (1440.)                  KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
    3    WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M   4       (1502.0)                 DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
M   5       (1499.0)                 DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
    5   SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M           (1535.0)    (10.0)       DELCOURT  69 CNTR   PHOTOPRODUCT.     8/69*

----------------   63  N*1/2(1535) WIDTH (MEV)   ----------------------

W            (130.0)                 HENDRY    65 RVUE                     9/66
W            (130.0)                 MICHAEL   66 RVUE                     7/66
W   N        (156.0) OR  144.0       UCHIYAMA- 66 RVUE   SEE NOTE ON MASS  9/66
W   1        (155.0)                 BAREYRE   68 RVUE                    11/67
W   2        (105.0)                 BAREYRE   68 RVUE                    11/67
W   3        (268.0)     APPROX      DONNACH1  68 RVUE                     6/68
W   3        (116.)                  DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
W   3        (160.)                  KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
W   4         (36.0)                 DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
W   5         (53.0)                 DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
W            (120.0)                 DELCOURT  69 CNTR   PHOTOPRODUCT.     8/69*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------   63  N*1/2(1535) PARTIAL DECAY MODES   ---------------

                                                           DECAY MASSES
P1          N*1/2(1535) INTO PI N                        139+ 938
P2          N*1/2(1535) INTO N ETA                       939+ 548
P3          N*1/2(1535) INTO N PI PI                     938+ 139+ 139

-----------------   63  N*1/2(1535) BRANCHING RATIOS   ------------------

R1          N*1/2(1535) INTO (PI N)/TCTAL                 (P1)/TOTAL
R1            (0.69)                 HENDRY    65 RVUE                     9/66
R1            (0.32)                 MICHAEL   66 RVUE                     9/66
R1  N         (0.71) OR  0.28        UCHIYAMA- 66 RVUE   SEE NOTE ON MASS  9/66
R1            (0.31)  OR   0.43      DAVIES    67 RVUE   PIP TC N ETA,B,C 11/67
R1  3         (0.696)                DONNACH1  68 RVUE                     6/68
R1  3          (.33)                 DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1  3          (.3)                  KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
R1  4         (0.36)                 DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
R1  5         (0.35)                 DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
R1            (0.33)                 DELCOURT  69 CNTR                     8/69*

R2          N*1/2(1535) INTO (N ETA)/TOTAL                (P2)/TOTAL
R2             DOMINANT INEL DECAY   HENDRY    65 RVUE                     9/66
R2            (0.68)                 MICHAEL   66 RVUE                     9/66
R2  N         (0.29) OR  0.71        UCHIYAMA- 66 RVUE   SEE NCTE ON MASS  9/66
R2            (0.69)  OR   0.45      DAVIES    67 RVUE   PIP TO N ETA,B,C 11/67
R2            (0.66)                 DELCOURT  69 CNTR                     8/69*
R2            (0.36)   (0.05)        DEANS     69 RVUE   T PCLE+RES ANAL   8/69*

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REFERENCES -- N*1/2(1535)


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HENDRY   65 PL 18 171         A W HENDRY, R G MOORHOUSE             (RTHFD)
      -- REVIEWS EARLY PHASE-SHIFT-ANALYSIS RESULTS AND PI- P TO ETA N
         EXPERIMENTS.  WE TAKE NUMBERS FROM THE SOLUTION USING BRANDSEN 65.
MICHAEL  66 PL 21 93          C MICHAEL                               (OXF)
UCHIYAMA 66 PR 149 1220       F UCHIYAMA-CAMPBELL, R K LOGAN       (ILL)IJP
DAVIES   67 NC 52A 1112       A T DAVIES, R G MOORHOUSE    (GLASGOW,RTHFD)

BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET    (SACLAY)IJP
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK           (GLAS)
DAVIES   68 VIENNA CONF.      A DAVIES,R MOORHOUSE                   (GLAS)
KIRSOPP  68 THESIS            R G KIRSOPP                            (EDIN)
DELCOURT 69 PL 29B 75         DELCOURT,LEFRANCOIS,PEREZ-Y-JORBA,+    (ORSA)
DEANS    69 PR 177 2623       S R DEANS                     (UNIV S FLORIDA)
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PAPERS NOT REFERRED TO IN DATA CARDS.

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BRANDSEN 65 PR 139 B1566      +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)IJP
      -- BASIS OF NUMBERS WE QUOTE FROM HENDRY 65.
BAREYRE  65 PL 18 342         + BRICMAN, STIRLING, VILLET       (SACLAY)IJP
LOVELACE 67 HEIDELBERG C. 79  C LOVELACE                          (CERN)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                             (LRL)

         THERE IS GETTING TO BE A WHOLE LITERATURE ON THE REACTIONS PI- P TO
         ETA N AND GAMMA P TO ETA P NEAR THRESHOLD AND THEIR CONNECTION WITH
         THE BEHAVIOR OF THE S11 AMPLITUDE AS DETERMINED IN PI P PHASE-SHIFT
         ANALYSIS.  THE READER IS INVITED TO PERUSE THE FOLLOWING RATHER IN-
         DIGESTIBLE COLLECTION.  FURTHER REFERENCES MAY BE FOUND IN THESE.

          MAINLY EXPERIMENTAL --
BULOS    64 PRL 13 486        +       (BROWN,BRANDEIS,HARVARD,MIT,PADOVA) I
RICHARDS 66 PRL 16 1221       +CHIU,EANDI,HELMHOLZ,KENNEY,+  (LRL,HAWAII) IJ
JONES    66 PL 23 597         +BINNIE,DUANE,HORSEY,MASON,+ (IMPCOL,RTHFD)
BACCI    66 NC 45A 983        +PENSO,SALVINI,MENCUCCINI,+ (ROME,FRASCATI)IJP
PREPOST  67 PRL 18 82         R PREPOST, D LUNDQUIST, D QUINN  (STANFORD)
BLOOM    68 PRL 21 1100       +HEUSCH, PRESCOTT, ROCHESTER      (CALTECH)
          MAINLY THEORETICAL --
DOBSON   66 PR 146 1022       P N DOBSON                           (HAWAII)
MINAMI   66 PR 147 1123       S MINAMI                              (OSAKA)
BALL     66 PR 149 1191       J S BALL                               (UCLA)
LOGAN    67 PR 153 1634       R K LOGAN, F UCHIYAMA-CAMPBELL          (ILL)
MENCUCCI 67 NC 48A 579        C MENCUCCINI, A REALE             (FRASCATI)
DEANS    67 PR 161 1466       S R DEANS, W G HOLLADAY         (VANDERBILT)
MINAMI   67 PR 162 1619       S MINAMI                              (OSAKA)
MOSS     67 PR 163 1785       T A MOSS                                (LSU)
DEANS    68 PR 165 1886       S R DEANS, W G HOLLADAY         (VANDERBILT)
PAL      68 PR 167 1350       B K PAL                      (NPL NEW DELHI)
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1520 MEV REGION – PRODUCTION EXPERIMENTS

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                    8 N*(1520)   PRODUCTION EXPERIMENTS

                    THIS INFORMATION REFERS TO EITHER THE D13 OR THE S11
                    STATE SEEN AT THIS MASS

R1          N*(1520)  INTO   (N PI)/TOTAL   PRODUCTION EXPERIMENTS
R1            0.78     0.24             BASSOMPIE 67 HBC  +  K+P TC K* N*     11/68

R2          N*(1520) INTO (NEUTRON PI+)/(P PI+ PI-)
R2            0.77     0.45             ALEXANDER 67 HBC  +  PP 5.5 BEV/C      9/66

R3          N*(1520) INTO (N PI)/(N PI PI)
R3            1.25     0.44      0.71   A-BORELLI 67 HBC  0  PBAR P 5.7 BEV/C  9/66

R4          N*(1520)  INTO   (N*3/2(1236) PI)/(N PI PI)   PROD. EXP.
R4            0.00     0.09             A-BORELLI 67 HBC                       9/66

R5          N*(1520) INTO (N PI PI)/TOTAL
R5           (0.08)    OR LESS          BASSOMPIE 67 HBC  +  K+P TO K* N*     11/68

R6          N*(1520)  INTO   (N ETA)/TOTAL          PROD. EXP.
R6            0.22     0.14             BASSOMPIE 67 HBC  +  K+P TO K* N*     11/68

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REFERENCES -N*(1520)- PROD. EXP.


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A-BORELL 67 NC 47 232         ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
ALEXANDE 67 PR 154 1284       ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
BASSOMPI 67 PL 25B 440        BASSOMPIERRE, +               (CERN,BRUXELLES)
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                    END PRODUCTION EXPERIMENTS

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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

N(1670) — D_{15}

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64  N*1/2(1670, JP=5/2-) I=1/2
    FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE

----------------  64  N*1/2(1670) MASS (MEV)  ----------------------

M         (1650.0)       APPROX     BRANDSEN  65 RVUE   PHASE-SHIFT ANAL  7/66
M         (1674.0)                  DUKE      68 CNTR   PI-P EL + POL     6/68
M    1    (1680.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     1          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2    (1655.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     2          WHERE SPEED IS GREATEST - EYEBALL FIT
M    3    (1678.0)                  DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M    3    (1680.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
M    3    (1678.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     3  WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M    4    (1669.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
M    5    (1667.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------  64  N*1/2(1670) WIDTH (MEV)  ----------------------

W    1     (135.0)                  BAREYRE   68 RVUE                    11/67
W    2     (105.0)                  BAREYRE   68 RVUE                    11/67
W    3     (173.0)                  DONNACH1  68 RVUE                     6/68
W    3     (173.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
W    3     (175.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
W    4     (115.0)                  DAVIES    68 RVUE     SOL A AND B     8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------  64  N*1/2(1670) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1        N*1/2(1670) INTO  PI N                      139+ 938
P2        N*1/2(1670) INTO  N ETA                     939+ 548
P3        N*1/2(1670) INTO  LAMBDA K                 1115+ 497
P4        N*1/2(1670) INTO N*3/2(1236) PI            1236+ 139
P5        N*1/2(1670) INTO N PI PI                    938+ 139+ 139

----------------  64  N*1/2(1670) BRANCHING RATIOS  ----------------

R1        N*1/2(1670) INTO (PI N)/TOTAL                (P1)/TOTAL
R1   1      (0.41)                  BAREYRE   68 RVUE                    11/67
R1   3      (0.391)                 DONNACH1  68 RVUE                     6/68
R1   3       (.39)                  DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1   3       (.39)                  KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
R1   4      (0.50)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
R1   5      (0.43)                  DAVIES    68 RVUE   P-S ANAL  SOL B.  8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2        N*1/2(1670) INTO (N ETA)/TOTAL               (P2)/TOTAL
R2          (0.025)     OR LESS     TRIPP     67 RVUE                     8/67
R2          (0.018)                 BOTKE     69 RVUE   T POLE+RES,FIT A 10/69*
R2          (0.003)  (0.004)        DEANS     69 RVUE   T PCLE+RES ANAL   8/69*

R3        N*1/2(1670) INTO (LAMBDA K)/TOTAL            (P3)/TOTAL
R3          (0.016)     OR LESS     TRIPP     67 RVUE                     8/67
R3          (0.001)     OR LESS     RUSH      68 RVUE   T-POLE+RES ANAL   8/69*

   SEE NOTE PRECEDING THE N*1/2(1688) INELASTIC DECAY MODE MEASUREMENTS.

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                         REFERENCES -- N*1/2(1670)

BRANDSEN 65 PL 19 420         +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)IJP
TRIPP    67 NP B3 10          + LEITH, +     (LRL,SLAC,CERN,HEIDEL,SACLAY)
BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET      (SACLAY)IJP
DAVIES   68 VIENNA CONF.      A DAVIES,R MOORHOUSE                    (GLAS)
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
DUKE     68 PR 166 1448       +JONES,KEMP,MURPHY,THRESHER, +  (RTHFD,OXF)IJP
      --  INSIGHTFUL QUALITATIVE ARGUMENTS CONCERNING EXISTENCE AND IJP.
KIRSOPP  68 THESIS            R G KIRSOPP                             (EDIN)
RUSH     68 PR 173 1776       J E RUSH                       (UNIV ALABAMA)
BOTKE    69 PR 180 1417       J C BOTKE                               (UCSB)
DEANS    69 PR 177 2623       S R DEANS                    (UNIV S FLORIDA)

                   PAPER NOT REFERRED TO IN DATA CARDS.

DUKE     65 PRL 15 468        +JONES,KEMP,MURPHY,PRENTICE, + (RTHFD,OXF)IJP
BAREYRE  65 PL 18 342         + BRICMAN, STIRLING, VILLET         (SACLAY)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                              (LRL)
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N(1688) — F_{15}

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65  N*1/2(1688, JP=5/2+) I=1/2
    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
    PRECEDING N*3/2(1236).

----------------  65  N*1/2(1688) MASS (MEV)  ----------------------

M         (1680.0)                  BRANDSEN  65 RVUE   PHASE SHIFT ANAL  7/66
M         (1682.0)                  DUKE      68 CNTR   PI-P EL + POL     6/68
M    1    (1690.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     1          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2    (1680.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     2          WHERE SPEED IS GREATEST - EYEBALL FIT
M    3    (1687.0)                  DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M    3    (1690.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
M    3    (1692.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     3  WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M    4    (1685.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
M    5    (1684.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------  65  N*1/2(1688) WIDTH (MEV)  ----------------------

W    1     (110.0)                  BAREYRE   68 RVUE                    11/67
W    2     (105.0)                  BAREYRE   68 RVUE                    11/67
W    3     (177.0)                  DONNACH1  68 RVUE                     6/68
W    3     (132.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
W    3     (130.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
W    4     (104.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
W    5     (123.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------  65  N*1/2(1688) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1        N*1/2(1688) INTO  PI N                      139+ 938
P2        N*1/2(1688) INTO  N ETA                     939+ 548
P3        N*1/2(1688) INTO  LAMBDA K                 1115+ 497
P4        N*1/2(1688) INTO N*3/2(1236) PI            1236+ 139
P5        N*1/2(1688) INTO N PI                       938+ 139+ 139
P6        N*1/2(1688)+ INTO NEUTRON PI+               939+ 139
P7        N*1/2(1688)+ INTO PROTON PI+ PI-            938+ 139+ 139
P8        N*1/2(1688)+ INTO N*3/2(1236)++ PI-        1236+ 139

----------------  65  N*1/2(1688) BRANCHING RATIOS.  ----------------

R1        N*1/2(1688) INTO (PI N)/TOTAL                (P1)/TOTAL
R1   1      (0.64)                  BAREYRE   68 RVUE                    11/67
R1   3      (0.560)                 DONNACH1  68 RVUE                     6/68
R1   3       (.68)                  DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1   3       (.68)                  KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
R1   4      (0.54)                  DAVIES    68 RVUE     SOL A AND B     8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

  MORE INFORMATICNS ON THE INELASTIC DECAY MODES OF THE 1690 MEV
  BUMP, AS SEEN IN PRODUCTION EXPERIMENTS, MAY BE FOUND IN THE NEXT ENTRY

R2        N*1/2(1688) INTO (N ETA)/TOTAL               (P2)/TOTAL
R2          (0.015)     OR LESS     TRIPP     67 RVUE                     8/67
R2          (0.0004)                BOTKE     69 RVUE   T POLE+RES,FIT A 10/69*
R2          (0.002)  (0.002)        DEANS     69 RVUE   T POLE+RES ANAL   8/69*

R3        N*1/2(1688) INTO (N ETA)/(PI N)              (P2)/(P1)
R3          (0.027)     OR LESS     HEUSCH    66 RVUE + PI0, ETA PHOTO    9/66

R4        N*1/2(1688) INTO (LAMBDA K)/TOTAL            (P3)/TOTAL
R4          (0.0013)    OR LESS     TRIPP     67 RVUE                     8/67
R4          (0.001)     OR LESS     RUSH      68 RVUE   T-POLE+RES ANAL   8/69*

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                         REFERENCES -- N*1/2(1688)

        SEE A PREVIOUS EDITION (RMP 37, 633, 1965) FOR EARLIER REFERENCES.

BRANDSEN 65 PL 19 420         +ODONNELL, MOORHOUSE          (DURHAM,RTHFD)IJP
HEUSCH   66 PRL 17 1019       C A HEUSCH, C Y PRESCOTT, R F DASHEN  (CIT)
TRIPP    67 NP B3 10          + LEITH, +     (LRL,SLAC,CERN,HEIDEL,SACLAY)
BAREYRE  68 PR 165 1731       P BAREYRE, C BRICMAN, G VILLET      (SACLAY)IJP
DAVIES   68 VIENNA CONF.      A DAVIES,R MOORHOUSE                    (GLAS)
DONNACH1 68 PL 26B 161        A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139        DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
DUKE     68 PR 166 1448       +JONES,KEMP,MURPHY,THRESHER, +  (RTHFD,OXF)IJP
KIRSOPP  68 THESIS            R G KIRSOPP                             (EDIN)
RUSH     68 PR 173 1776       J E RUSH                       (UNIV ALABAMA)

BOTKE    69 PR 180 1417       J C BOTKE                               (UCSB)
DEANS    69 PR 177 2623       S R DEANS                    (UNIV S FLORIDA)

                   PAPERS NOT REFERRED TO IN DATA CARDS.

DUKE     65 PRL 15 468        +JONES,KEMP,MURPHY,PRENTICE, +  (RTHFD,OXF)IJP
CROUCH   65 DESY CONF II 21   +   (BROWN,CEA,HARVARD,MIT,PADOVA,WEIZMANN)
DERADO   65 ATHENS CONF 244   +KENNEY,LAMSA, +       (NOTRE DAME,KENTUCKY)
MERLO    66 P ROY SOC 289 489 J P MERLO, G VALLADAS                 (SACLAY)
ROBERTS  67 PREPRINT          R G ROBERTS                           (DURHAM)
BANNER   68 PR 166 1347       +DETOEUF,FAYOUX,HAMEL, +         (SACLAY,CAEN)
      --  THE ABOVE PAPERS DISCUSS INELASTIC CHANNELS NEAR THE BUMP.
BAREYRE  65 PL 18 342         + BRICMAN, STIRLING, VILLET         (SACLAY)IJP
JOHNSCN  67 UCRL-17683 THESIS C H JOHNSON                              (LRL)
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N(1700) — S''_{11}

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66  N*1/2(1700, JP=1/2-) I=1/2
    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
    PRECEDING N*3/2(1236).

----------------  66  N*1/2(1700) MASS (MEV)  ----------------------

M         (1695.0)                  BRANDSEN  65 RVUE   PHASE-SHIFT ANAL  9/66
M         (1700.0)                  MICHAEL   66 RVUE   FITS BAREYRE S11  7/66
M    1    (1710.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     1          WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2    (1665.0)                  BAREYRE   68 RVUE   PHASE-SHIFT ANAL 11/67
     2          WHERE SPEED IS GREATEST - EYEBALL FIT
M    3    (1710.0)                  DONNACH1  68 RVUE   PHASE-SHIFT ANAL  8/68
M    3    (1710.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
M    3    (1709.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
     3  WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M    4    (1766.0)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
M    5    (1671.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
     5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M    6    (1705.0)   (10.0)         ORITO     69 RVUE   K LAMBDA PS ANAL  8/69*

----------------  66  N*1/2(1700) WIDTH (MEV)  ----------------------

W          (240.0)                  MICHAEL   66 RVUE                     7/66
W    1     (260.0)                  BAREYRE   68 RVUE                    11/67
W    2     (110.0)                  BAREYRE   68 RVUE                    11/67
W    4     (404.0)                  DAVIES    68 RVUE   P-S ANAL ,SOL A   8/69*
W    5     (121.0)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
W    3     (300.0)                  DONNACH1  68 RVUE                     8/69*
W    3     (300.)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
W    3     (300.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
W    6     (104.0)   (15.0)         ORITO     69 RVUE                     8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------  66  N*1/2(1700) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1        N*1/2(1700) INTO PI N                       139+ 938
P2        N*1/2(1700) INTO N ETA                      939+ 548
P3        N*1/2(1700) INTO LAMBDA K                  1115+ 497

----------------  66  N*1/2(1700)  BRANCHING RATIOS  ----------------

R1        N*1/2(1700) INTO (PI N)/TOTAL                (P1)/TOTAL
R1          (1.0)        APPROX     MICHAEL   66 RVUE                     7/66
R1   4      (0.56)                  DAVIES    68 RVUE   P-S ANAL  SOL A   8/69*
R1   5      (0.51)                  DAVIES    68 RVUE   P-S ANAL  SOL B   8/69*
R1   3      (0.79)                  DONNACH1  68 RVUE                     8/69*
R1   3       (.79)                  DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1   3       (.79)                  KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
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Data in parentheses have not been included in our averages.

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R2    N*1/2(1700) INTO (LAMBDA K)*(PI N)/TOTAL**2          (P3*P1)/TOTAL**2
R2           0.039     0.019          ORITO      69 RVUE                       8/69*

R3          N*1/2(1700) INTO (LAMBDA K)/TOTAL               (P3)/TOTAL
R3            (0.028)        APPROX       RUSH       68           T-POLE+RES ANAL   8/69*

R4          N*1/2(1700) INTO (N ETA)/TOTAL                  (P2)/TOTAL
R4            (0.013)                     BOTKE      69 RVUE    T POLE+RES,FIT A 10/69*
R4            (0.041)   (0.016)           DEANS      69 RVUE    T POLE+RES ANAL   8/69*

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                              REFERENCES -- N*1/2(1700)

BRANDSEN 65 PL 19 420            +ODONNELL, MCORHOUSE            (DURHAM,RTHFD)IJP
MICHAEL  66 PL 21 93             C MICHAEL                                  (OXF)
BAREYRE  68 PR 165 1731          P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DAVIES   68 VIENNA CONF.         A DAVIES,R MOORHOUSE                      (GLAS)
DONNACH1 68 PL 26B 161           A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139           DONNACHIE  RAPPORTEUR.S TALK              (GLAS)
KIRSOPP  68 THESIS               R G KIRSOPP                               (EDIN)
RUSH     68 PR 173 1776          J E RUSH                         (UNIV ALABAMA)

BOTKE    69 PR 180 1417          J C BOTKE                                 (UCSB)
DEANS    69 PR 177 2623          S R DEANS                     (UNIV S FLORIDA)
ORITO    69 LNC 1 936            S ORITO,S SASAKI                   (TOKYO-OSAKA)

                    PAPERS NOT REFERRED TO IN DATA CARDS.

BAREYRE  65 PL 18 342            + BRICMAN, STIRLING, VILLET         (SACLAY)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                                   (LRL)

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N(1700) **D''13**

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            18  N*1/2(1700,JP=3/2-) I=1/2

            FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
            PRECEDING N*3/2(1236).

---------------- 18  N*1/2(1700) MASS  (MEV)   -----------------------

M   3     (1680.)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
M   3     (1730.)                      DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1    10/69*

---------------- 18  N*1/2(1700) WIDTH (MEV)   -----------------------

---------------- 18  N*1/2(1700) PARTIAL DECAY MODES     ----------------

                                                          DECAY MASSES
P1         N*1/2(1700) INTO PI N                          139+ 938

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                              REFERENCES -- N*1/2(1700)

DONNACH2 68 VIENNA 139           DONNACHIE  RAPPORTEUR.S TALK              (GLAS)
KIRSOPP  68 THESIS               R G KIRSOPP                               (EDIN)

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1700 MEV REGION – PRODUCTION EXPERIMENTS

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                 20  N*(1700) PRODUCTION EXPERIMENTS

---------------- 20  N* (1700)   MASS (MEV)   ------------------------

M        (1695.0)    (9.0)            A-BORELLI 67 HBC  +  PBAR P 5.7 BEV/C   8/67
M        (1734.0)    (21.0)           ALMEIDA   68 HBC  +  PP 10 BEV/C        9/69*
M        (1730.0)    (18.0)           GALLOWAY  68 HBC     PI-P 6 GEV/C       8/69*
M     190(1693.)     (15.)            JESPERSEN 68 HBC     PP 22 GEV/C       10/69*

---------------- 20  N* (1700)   WIDTH (MEV)   -----------------------

W         (70.0)    (20.0)            A-BORELLI 67 HBC                        9/69*
W        (140.0)    (57.0)            ALMEIDA   68 HBC  +                     9/69*
W         (55.0)    (15.0)            GALLOWAY  68 HBC                        8/69*
W     190 (235.)    (50.)             JESPERSEN 68 HBC     PP 22 GEV/C       10/69*

---------------- 20  N*(1700)    BRANCHING RATIOS      ---------------

R1         N*   (1700) INTO (PI N)/(PI N*3/2(1236))        PROD. EXP.
R1           (0.77)   OR LESS         LEE        67 HBC                      11/67

R2         N*   (1700) INTO (N ETA)/TOTAL                  PROD. EXP.
R2           (0.025)      OR LESS     KRAEMER    64 DBC  +  PI+D 1.23 BEV/C   9/66
R2           (0.042)OR LESS (95PC CL) A-BORELLI 67 HBC  +  PBAR P 5.7 BEV/C   9/69*

R3         N*   (1700) INTO (LAMBDA K)/(P PI+ PI-)         PROD. EXP.
R3           (0.034)      OR LESS     ALEXANDER 67 HBC  +  PP 5.5 BEV/C      11/67

R4         N*   (1700) INTO (LAMBDA K)/TOTAL               PROD. EXP.
R4           (0.013)OR LESS (95PC CL) A-BORELLI 67 HBC  +                     8/67
R4             SEEN                   CHINOWSKY 68 HBC     PP TO K+ Y N       6/68

R5         N*   (1700) INTO (N PI)/(N PI PI)               PROD. EXP.
R5           (1.26)OR LESS (95PC CL)  A-BORELLI 67 HBC  +                     8/67

R6         N*   (1700) INTO (N*3/2(1236) PI)/(N PI PI)     PROD. EXP.
R6            NO EVIDENCE             A-BORELLI 67 HBC  +                     8/67
           SEE MERLO 66 FOR A REVIEW.

R7         N*   (1700) INTO (NEUTRON PI+)/(P PI+ PI-)      PROD. EXP.
R7            0.67      0.40          ALEXANDER 67 HBC  +  PP 5.5 BEV/C      11/67

R8         N*   (1700) INTO (N*(1236)++ PI-)/(P PI+ PI-) PROD. EXP.
R8            0.74      0.14          ALEXANDER 67 HBC  +  PP 5.5 BEV/C      11/67
R8           (1.0)             0.3    ALMEIDA   68 HBC  +  PP 10 BEV/C        9/66
R8           (0.83)                   KAYAS     68     HBC PP 8.1 BEV/C      11/68

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                      REFERENCES -- N* IN PRODUCT EXPERIMENTS

KRAEMER  64 PR 136 B496          +MADANSKY,+  (J HOPKINS,NWESTERN,WOODSTOCK) I
ALEXANDE 67 PR 154 1284          ALEXANDER,BENARY,CZAPEK,+  (WEIZMANN(CERN))
A-BORELL 67 NC 47 232            ALLES-BORELLI,FRENCH,FRISK,MICHEJDA  (CERN)
LEE      67 PR 159 1156          +MOEBS,ROE,SINCLAIR,VANDER VELDE     (MICH)

ALMEIDA  68 PR 174 1638          +RUSHBROOKE, +           (CAVNDSH,DESY(CERN))
CHINOWSK 68 PR 165 1466          CHINOWSKY,KINSEY,KLEIN, +          (LRL,SLAC)
JESPERSE 68 PRL 18 1368          JESPERSEN,KANG,KERNAN,LEACOCK,RHODE+ (IOWA)
KAYAS    68 NP B5 169            +GUYADER,SENE,YIOU,ALITTI,+  (ORSAY,SACLAY)
GALLOWAY 68 PL 27B 250           GALLOWAY,ALYEA,CRITTENDEN,PRICKETT,+ (IND)
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                   PAPERS NOT REFERRED TO IN DATA CARDS

MERLO    66 P ROY SOC 289 489 J P MERLO, G VALLADAS                 (SACLAY)

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                        END PRODUCTION EXPERIMENTS

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N(1780) **P''11**

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            14  N*1/2(1780, JP=1/2+) I=1/2

            FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
            PRECEDING N*3/2(1236).

---------------- 14  N*1/2(1780) MASS (MEV)   -------------------------

M   3     (1751.0)                    DONNACH1   68 RVUE    PHASE-SHIFT ANAL  8/69*
M   3     (1750.)                     DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
M   3     (1860.)                     KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1   10/69*
M   4     (1770.0)                    DAVIES     68 RVUE    P-S ANAL  SOL A   8/69*
M   5     (1867.0)                    DAVIES     68 RVUE    P-S ANAL  SOL B   8/69*
    5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M   6     (1640.0)    (70.0)          ORITO      69 RVUE    K LAMBDA PS ANAL  8/69*

---------------- 14  N*1/2(1780) WIDTH (MEV)   ------------------------

W   3     (327.0)                     DONNACH1   68 RVUE                      8/69*
W   3     (327.)                      DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
W   3     (270.)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
W   4     (445.0)                     DAVIES     68 RVUE               SOL A  8/69*
W   5     (525.0)                     DAVIES     68 RVUE               SOL B  8/69*
W   6     (310.0)    (50.0)           ORITO      69 RVUE                      8/69*
        SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.P EY

---------------- 14  N*1/2(1780) PARTIAL DECAY MODES     ---------------

                                                          DECAY MASSES
P1         N*1/2(1780) INTO  PI N                         139+ 938
P2         N*1/2(1780) INTO  LAMBDA K                    1115+ 497
P3         N*1/2(1780) INTO  N ETA                        939+ 548

---------------- 14  N*1/2(1780) BRANCHING RATIOS    ------------------

R1         N*1/2(1780) INTO (PI N)/TOTAL                   (P1)/TOTAL
R1  3       (0.32)                    DONNACH1   68 RVUE                      8/69*
R1  3       (.32)                     DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
R1  3       (.32)                     KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
R1  4       (0.43)                    DAVIES     68 RVUE               SOL A  8/69*
R1  5       (0.30)                    DAVIES     68 RVUE               SOL B  8/69*

R2    N*1/2(1780) INTO (LAMBDA K)*(PI N)/TOTAL**2          (P2*P1)/TOTAL**2
R2           0.004     0.003          ORITO      69 RVUE                      8/69*

R3         N*1/2(1780) INTO (LAMBDA K)/TOTAL               (P2)/TOTAL
R3          (0.003)TO  0.065          RUSH       68 RVUE     T-POLE+RES ANAL  8/69*

R4         N*1/2(1780) INTO (N ETA)/TOTAL                  (P3)/TOTAL
R4          (0.1)      (0.04)         DEANS      69 RVUE     T POLE+RES ANAL  8/69*
R4          (0.19)                    BOTKE      69 RVUE     T POLE+RES,FIT A 10/69*

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                              REFERENCES -- N*1/2(1780)

DAVIES   68 VIENNA CONF.         A DAVIES,R MOORHOUSE                      (GLAS)
DONNACH1 68 PL 26B 161           A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139           DONNACHIE  RAPPORTEUR.S TALK              (GLAS)
KIRSOPP  68 THESIS               R G KIRSOPP                               (EDIN)
RUSH     68 PR 173 1776          J E RUSH                         (UNIV ALABAMA)
BOTKE    69 PR 180 1417          J C BOTKE                                 (UCSB)
DEANS    69 PR 177 2623          S R DEANS                     (UNIV S FLORIDA)
ORITO    69 LNC 1 936            S ORITO,S SASAKI                   (TOKYO-OSAKA)

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N(1860) **P13**

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            15  N*1/2(1860, JP=3/2+) I=1/2

            FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
            PRECEDING N*3/2(1236).

---------------- 15  N*1/2(1860) MASS (MEV)   -------------------------

M   3     (1860.0)                    DONNACH1   68 RVUE    PHASE-SHIFT ANAL  6/68
M   3     (1860.)                     DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
M   3     (1900.)                     KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1    10/69*
M   4     (1844.0)                    DAVIES     68 RVUE    P-S ANAL  SOL A   8/69*
M   5     (1854.0)                    DAVIES     68 RVUE    P-S ANAL  SOL B   8/69*
    5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)
M         (1860.0)          APPROX    LEA        69 CNTR    PI-P ELASTIC      8/69*

---------------- 15  N*1/2(1860) WIDTH (MEV)   ------------------------

W   3     (296.00)                    DONNACH1   68 RVUE                      8/69*
W   3     (296.)                      DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
W   3     (325.)                      KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
W   4     (449.0)                     DAVIES     68 RVUE               SOL A  8/69*
W   5     (307.0)                     DAVIES     68 RVUE               SOL B  8/69*
                SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

---------------- 15  N*1/2(1860) PARTIAL DECAY MODES     ---------------

                                                          DECAY MASSES
P1         N*1/2(1860) INTO  PI N                         139+ 938
P2         N*1/2(1860) INTO  LAMBDA K                    1115+ 497
P3         N*1/2(1860) INTO N ETA                         939+ 548
P4         N*1/2(1860) INTO N PI PI                       938+ 139+ 139

---------------- 15  N*1/2(1860) BRANCHING RATIOS    ------------------

R1         N*1/2(1860) INTO (PI N)/TOTAL                   (P1)/TOTAL
R1  3       (0.21)                    DONNACH1   68 RVUE                      8/69*
R1  3       (.21)                     DONNACH2   68 RVUE    PHAS.SHIFT-CERN1 10/69*
R1  3       (.25)                     KIRSOPP    68 RVUE    PHASE SHIFT ANAL 10/69*
R1  4       (0.40)                    DAVIES     68 RVUE               SOL A  8/69*
R1  5       (0.26)                    DAVIES     68 RVUE               SOL B  8/69*

R2         N*1/2(1860) INTO (LAMBDA K)/TOTAL               (P2)/TOTAL
R2          (0.014) TO  0.16          RUSH       68 RVUE     T-POLE+RES ANAL  8/69*

R3         N*1/2(1860) INTO (N ETA)/TOTAL                  (P3)/TOTAL
R3          (0.0364)                  BOTKE      69 RVUE     T POLE+RES,FIT A 10/69*

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Data in parentheses have not been included in our averages.

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                         REFERENCES -- N*1/2(1860)

DAVIES    68 VIENNA CONF.     A DAVIES,R MOORHOUSE                     (GLAS)
DONNACH1  68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2  68 VIENNA 139       DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP   68 THESIS           R G KIRSOPP                              (EDIN)
RUSH      68 PR 173 1776      J E RUSH                        (UNIV ALABAMA)
BOTKE     69 PR 180 1417      J C BOTKE                                (UCSB)
LEA       69 PL 29B 584       LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

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N(1990) F_{17}

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17  N*1/2(1990, JP=7/2+) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  17  N*1/2(1990) MASS (MEV)  ----------------------

M   3     (1983.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL
M   3     (1995.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M         (2000.0)        APPROX    LEA        69 CNTR    PI-P ELASTIC      8/69*

----------------  17  N*1/2(1990) WIDTH (MEV)  ---------------------

W   3      (225.0)                  DONNACH1  68 RVUE                       8/69*
W   3      (250.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*

--------------  17 N*1/2(1990) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1          N*1/2(1990) INTO PI N                      139+ 938
P2          N*1/2(1990) INTO N PI PI                   938+ 139+ 139

--------------  17 N*1/2(1990) BRANCHING RATIOS  -------------------

R1          N*1/2(1990) INTO (PI N)/TOTAL             (P1)/TCTAL
R1  3           (.09)               KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*

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                         REFERENCES -- N*1/2(1990)

DCNNACH1  68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP   68 THESIS           R G KIRSOPP                              (EDIN)
LEA       69 PL 29B 584       LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

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N(2040) D'''_{13}

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16  N*1/2(2040, JP=3/2-) I=1/2

FOR DISCUSSION CCNCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  16  N*1/2(2040) MASS (MEV)  ----------------------

M   3     (2057.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3     (2030.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
M   3     (2040.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M         (2030.0)        APPROX    LEA        69 CNTR    PI-P ELASTIC      8/69*

----------------  16  N*1/2(2040) WIDTH (MEV)  ---------------------

W         (93.0 30)                 DCNNACH1  68 RVUE                       8/69*
W   3      (290.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
W   3      (240.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

--------------  16 N*1/2(2040) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1          N*1/2(2040) INTO  PI N                     139+ 938
P2          N*1/2(2040) INTO N PI PI                   938+ 139+ 139

--------------  16 N*1/2(2040) BRANCHING RATIOS  -------------------

R1          N*1/2(2040) INTO (PI N)/TOTAL             (P1)/TOTAL
R1  3           (.26)               DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
R1  3           (.15)               KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*

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                         REFERENCES -- N*1/2(2040)

DONNACH1  68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2  68 VIENNA 139       DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP   68 THESIS           R G KIRSOPP                              (EDIN)
LEA       69 PL 29B 584       LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

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N(2190) G_{17}

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71  N*1/2(2190, JP=7/2-) I=1/2

FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  71  N*1/2(2190) MASS (MEV)  ----------------------

M         (2190.0)                  DIDDENS   63 CNTR    PI+- P TOTAL
M         (2210.0)                  HOHLER    64 RVUE    DATA + DISP REL
M         (2190.0)        APPROX    YOKOSAWA  66 CNTR    PI- P DSIG + POL  7/66
M   3     (2265.0)                  DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M   3     (2190.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
M   3     (2265.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
    3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M         (2000.0)        APPROX    LEA        69 CNTR    PI-P ELASTIC      8/69*

----------------  71  N*1/2(2190) WIDTH (MEV)  ---------------------

W          (200.0)                  DIDDENS   63 CNTR
W          (200.0)                  HOHLER    64 RVUE                       7/66
W          (220.0)        APPROX    YOKOSAWA  66 CNTR                       7/66
W   3      (298.0)                  DONNACH1  68 RVUE                       6/68
W   3      (300.)                   DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
W   3      (300.)                   KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.P EY

--------------  71  N*1/2(2190) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1          N*1/2(2190) INTO PI N                      139+ 938
P2          N*1/2(2190) INTO LAMBDA K                  1115+ 497
P3          N*1/2(2190) INTC N PI PI                   938+ 139+ 139

--------------  71  N*1/2(2190) BRANCHING RATIOS  -------------------

R1          N*1/2(2190) INTO (PI N)/TOTAL             (P1)/TOTAL
R1              (0.3)      APPROX   DIDDENS   63 CNTR                       7/66
R1              (0.3)      APPROX   YOKOSAWA  66 CNTR                       7/66
R1  3          (0.349)              DONNACH1  68 RVUE                       6/68
R1  3           (.35)               DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
R1  3           (.35)               KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*

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                         REFERENCES -- N*1/2(2190)

DIDDENS   63 PRL 10 262       +JENKINS, KYCIA, RILEY                  (BNL) I
HOHLER    64 PL 12 149        G HOHLER, J GIESECKE              (KARLSRUHE) I
YOKOSAWA  66 PRL 16 714       +SUWA,HILL,ESTERLING,BOOTH           (ARG,CHI) JP
DONNACH1  68 PL 26B 161       A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2  68 VIENNA 139       DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP   68 THESIS           R G KIRSOPP                              (EDIN)
LEA       69 PL 29B 584       LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DARE)

        QUANTUM NUMBER DETERMINATIONS NOT REFERRED TO IN DATA CARDS.

CARROLL   66 PRL 16 288       +CORBETT,DAMERELL,MIDDLEMAS, +  (RTHFD,OXF)J-L
CARROLL   66 PRL 17 1274      +CORBETT,DAMERELL,MIDDLEMAS, +  (RTHFD,OXF)J-L
     --  ERRATUM CHANGING THE RATHER WEAK DETERMINATION OF J-L TO +1/2.
KORMANYO  66 PRL 16 709       KORMANYOS,KRISCH,OFALLON, +        (MICH,ARG) P
BARGER    66 PRL 16 913       V BARGER, D CLINE                        (WISC) P
BUSZA     67 NC 52A 331       +DAVIS,DUFF,HEYMANN, +  (UNICOL,WESTFIELD)

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M > 2200 MEV — PRODUCTION AND σ_{TOTAL} EXPERIMENTS

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N(2650)

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72  N*1/2(2650, JP=    -) I=1/2

----------------  72  N*1/2(2650) MASS (MEV)  ----------------------

M         (2700.0)                  ALVAREZ   64 CNTR    PI PHOTOPROD
M         (2600.0)        APPROX    WAHLIG    64 OSPK 0  PI-P CH EX
M         (2660.0)                  HOHLER    64 RVUE    DATA + DISP REL
M          2649.0     10.0          CITRON    66 CNTR    PI+- P TOTAL      7/66
M         (2633.0)                  BARGER    66 FIT     TOTAL + CH EX    11/67

----------------  72  N*1/2(2650) WIDTH (MEV)  ---------------------

W          (100.0)                  ALVAREZ   64 CNTR
W          (200.0)                  HOHLER    64 RVUE                      7/66
W           360.0     20.0          CITRON    66 CNTR                      7/66
W          (425.0)                  BARGER    66 FIT     TOTAL + CH EX    11/67

----------------  72  N*1/2(2650) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1          N*1/2(2650) INTO PI N                      139+ 938
P2          N*1/2(2650) INTO LAMBDA K                  1115+ 497
P3          N*1/2(2650) INTO N PI PI                   938+ 139+ 139

----------------  72  N*1/2(2650) BRANCHING RATIOS  -------------------

R1          N*1/2(2650) INTO (PI N)/TOTAL             (P1)/TOTAL
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1              0.436    0.028      CITRON    66 CNTR    TOTAL CROSS-SEC. 11/67
R1  B          (0.456)  (0.018)     BARGER    66 RVUE    TOTAL + CH EXC.  11/67
R1  B          (0.30)               BARGER    67 RVUE    USES KORMANYOS67 11/67
    B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
    B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D          (0.24)               DIKMEN    67 RVUE    USES KORMANYOS66 11/67
    D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1             (0.06)               KORMANYOS 67 CNTR    PI-P AT 180 DEG. 11/67

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                         REFERENCES -- N*1/2(2650)

ALVAREZ   64 PRL 12 710       +BAR-YAM,KERN,LUCKEY,OSBORNE, +    (MIT,CEA)
WAHLIG    64 PRL 13 103       +MANNELLI,SODICKSON,FACKLER,WARD, +   (MIT)
HOHLER    64 PL 12 149        G HOHLER, J GIESECKE              (KARLSRUHE) I
CITRON    66 PR 144 1101      +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER    66 PR 151 1123      V BARGER, M OLSSON                       (WISC)
BARGER    67 PR 155 1792      V BARGER, D CLINE                        (WISC) P
DIKMEN    67 PRL 18 798       F N DIKMEN                               (MICH)
KCRMANYO  67 PR 164 1661      KORMANYOS, KRISCH, OFALLON, +      (MICH,ARG) P
DOLEN     68 PR 166 1768      R DOLEN, D HORN, C SCHMID            (CAL TECH)

                 PAPER NOT REFERRED TO IN DATA CARDS.

BAACKE    67 NC 51A 761       J BAACKE, M YVERT           (KARLSRUHE,ORSAY)J-L
WAHLIG    68 PR 168 1515      M A WAHLIG, I MANNELLI                (MIT,PISA)
     --  FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
         CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
         COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

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N(3030)

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73  N*1/2(3030, JP=      ) I=1/2

----------------  73  N*1/2(3030) MASS (MEV)  ----------------------

M         (3080.0)                  HOHLER    64 RVUE    DATA + DISP REL   7/66
M         (3030.0)                  CITRON    66 CNTR    PI+- P TOTAL      7/66

----------------  73  N*1/2(3030) WIDTH (MEV)  ---------------------

W          (400.0)                  CITRON    66 CNTR                      7/66

----------------  73  N*1/2(3030) PARTIAL DECAY MODES  ----------------

                                                       DECAY MASSES
P1          N*1/2(3030) INTO PI N                      139+ 938
P2          N*1/2(3030) INTO N PI PI                   938+ 139+ 139
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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-----------------   73  N*1/2(3030) BRANCHING RATIOS   ------------------

R1          N*1/2(3030) INTO (PI N)/TOTAL                      (P1)/TOTAL
R1     ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1            (0.048)                   CITRON    66 CNTR    TOTAL CROS.SEC.  11/67
R1   B        (0.088)  (0.016)          BARGER    66 RVUE    TOTAL + CH EXC.  11/67
R1   B        (0.12)                    BARGER    67 CNTR    USES KORMANYOS66 11/67
     B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
     B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1   D        (0.016)                   DIKMEN    67  RVUE   USES KORMANYOS67 11/67
     D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES

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                           REFERENCES -- N*1/2(3030)

HOHLER   64 PL 12 149          G HOHLER, J GIESECKE              (KARLSRUHE) I
CITRON   66 PR 144 1101        +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER   66 PR 151 1123        V BARGER, M OLSSON                     (WISC)
BARGER   67 PR 155 1792        V BARGER, D CLINE                      (WISC) P
DIKMEN   67 PRL 18 798         F N DIKMEN                             (MICH)
KORMANYO 67 PR 164 1661        KORMANYOS, KRISCH, OFALLON, +    (MICH,ARG) P
DOLEN    68 PR 166 1768        R DOLEN, D HORN, C SCHMID          (CAL TECH)

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N? (3245)

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                    74  N*   (3245, JP=    +)

                     EXISTENCE NOT CONCLUSIVELY ESTABLISHED.  I-SPIN
                     NOT DETERMINED, BUT THE NARROW WIDTH PRECLUDES
                     IDENTIFICATION WITH THE N*3/2(3230).  OMITTED
                ---> FROM TABLE.

----------------   74  N* /2(3245) MASS (MEV)   ------------------------

M          3245.0     10.0            KORMANYOS 67 CNTR    PI-P 180 DEG EL   6/68

----------------   74  N* /2(3245) WIDTH (MEV)   -----------------------

W           (35.0)    OR LESS         KORMANYOS 67 CNTR                      6/68

----------------   74  N* /2(3245) PARTIAL DECAY MODES   ---------------

                                                        DECAY MASSES
P1         N* /2(3245) INTO PI N                      139+ 938

----------------   74  N* /2(3245) BRANCHING RATIOS   ------------------
      J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(PI N)/TOTAL
R1          (0.37)                    KORMANYOS 67 CNTR                      6/68

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                           REFERENCES -- N* /2(3245)

KORMANYO 67 PR 164 1661        KORMANYOS, KRISCH, OFALLON, +    (MICH,ARG) P

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N(3690)

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                    75  N*1/2(3690, JP=     ) I=1/2

                     A BUMP SEEN IN THE INVARIANT MASS OF A VERY COMPLI-
                     CATED STATE (N + SEVEN PIS), SO AS EVIDENCE FOR
                     A NEW RESONANCE IT IS NOT CONCLUSIVE.  NOT INCLUDED
                ---> IN TABLE.

----------------   75  N*1/2(3690) MASS (MEV)   ------------------------

M          3690.0     10.0            BARTKE    67 HBC   + PI+P 8 PRONGS     8/67

----------------   75  N*1/2(3690) WIDTH (MEV)   -----------------------

W            50.0     30.0            BARTKE    67 HBC   +                   8/67

----------------   75  N*1/2(3690) PARTIAL DECAY MODES   ---------------

                                                        DECAY MASSES
P1         N*1/2(3690) INTO N + 7 PIS                 2250

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                           REFERENCES -- N*1/2(3690)

BARTKE   67 PL 24B 118        +CZYZEWSKI,DANYSZ, +   (CRACOW,ORSAY(CERN)) I

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N? (3755)

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                    76  N* /2(3755, JP=     )

                     A SMALL PEAK IN THE (P P PBAR) INVARIANT MASS FROM
                     8.4 BEV/C PI+ P TO PI+ P P PBAR EVENTS.  AS EVIDENCE
                     FOR A NEW RESONANCE IT IS NOT CONCLUSIVE.  OMITTED
                ---> FROM TABLE.

----------------   76  N* /2(3755) MASS (MEV)   ------------------------

M          3755.0      8.0            EHRLICH   68 HBC  +  PI+ P P PBAR      6/68

----------------   76  N* /2(3755) WIDTH (MEV)   -----------------------

W            40.0     20.0            EHRLICH   68 HBC  +                    6/68

----------------   76  N* /2(3755) PARTIAL DECAY MODES   ---------------

                                                        DECAY MASSES
P1         N* /2(3755) INTO PI+ P P PBAR

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                           REFERENCES -- N* /2(3755)

EHRLICH  68 PRL 20 686         R EHRLICH,R J PLANO,J B WHITTAKER (RUTGERS)

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                    END PRODUCTION EXPERIMENTS

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Δ(1236) — **P'_{33}**

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                    81  N*3/2(1236, JP=3/2+) I=3/2

                   81  N*3/2(1236) MASS (MEV)   -----------------------

M         (1234.0)                    ROPER     65 RVUE 0++PHASE-SHIFT ANAL
M++        1236.0      0.55           OLSSON    65 RVUE ++ TOTAL-SIGMA DATA
M++       (1232.0)    (6.0)           FERRO-LUZ 65 HBC  ++ K+P TO KO P PI+
M++       (1233.4)    (4.4)           GIDAL     66 DBC  ++ D D TO NN(NN) PI  7/66
M++       (1236.0)                    DEANS     66 RVUE ++ PI+P TOTAL        7/66
MO         1236.45     0.65           OLSSON    65 RVUE 0
M-        (1241.3)    (5.1)           GIDAL     66 DBC  -                    7/66

----------------   81  N*(0) - N*(++) MASS DIFFERENCE (MEV)   ----------

D    R       (0.45)   (0.85)          OLSSON    65 RVUE
D    R      REDUNDANT WITH DATA IN MASS LISTING.

----------------   81  N*(-) - N*(++) MASS DIFFERENCE (MEV)   ----------

D              7.9      6.8           GIDAL     66 DBC

----------------   81  N*3/2(1236) WIDTH (MEV)   -----------------------

W++         120.0      2.0            OLSSON    65 RVUE ++
W++        (125.0)   (30.0)           FERRO-LUZ 65 HBC  ++
W++        (124.0)   (14.0)           GIDAL     66 DBC  ++                   7/66
W++        (121.0)                    DEANS     66 RVUE ++                   7/66
WO          119.6      2.4            OLSSON    65 RVUE 0
W-         (149.0)   (18.0)           GIDAL     66 DBC  -                    7/66

----------------   81  N*3/2(1236) PARTIAL DECAY MODES   ---------------

                                                        DECAY MASSES
P1         N*3/2(1236) INTO PI N                      139+ 938
P2         N*3/2(1236) INTO N GAMMA                     0+ 938
P3         N*3/2(1236) INTO N PI PI                   938+ 139+ 139

----------------   81  N*3/2(1236) BRANCHING RATIOS   ------------------

R1     N*3/2(1236) INTO (N GAMMA)/TOTAL   (PERCENT)      (P2)/(P1)
R1             0.55      0.02         DALITZ    66 RVUE                      7/68

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                           REFERENCES -- N*3/2(1236)

OLSSON   65 PRL 14 118         M G OLSSON                             (WISC)
FERRO-LU 65 NC 36 1101         FERRO-LUZZI,GEORGE, +                  (CERN)
ROPER    65 PR 138 B190        L D ROPER, R M WRIGHT, B T FELD  (LRL,MIT) JP
DALITZ   66 PR 146 1180        DALITZ,SUTHERLAND                    (OXFORD)
DEANS    66 PREPRINT           S R DEANS, W G HOLLADAY         (VANDERBILT)
GIDAL    66 PR 141 1261        G GIDAL, A KERNAN, S KIM                (LRL)

       FOR EXTENSIVE REFERENCES TO DATA AND PHASE-SHIFT ANALYSES TILL 1965,
       SEE ROPER 65, ESPECIALLY APPENDIX II.

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Δ(1650) — **S_{31}**

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                    82  N*3/2(1650, JP=1/2-) I=3/2

                    FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                    PRECEDING N*3/2(1236).

----------------   82  N*3/2(1650) MASS (MEV)   ------------------------

M          (1648.0)   (12.0)          DEVLIN    65 CNTR    PI+- P TOTAL
M    1     (1695.0)                   BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
     1           WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M    2     (1650.0)                   BAREYRE   68 RVUE    PHASE-SHIFT ANAL 11/67
     2           WHERE SPEED IS GREATEST - EYEBALL FIT
M    3     (1635.0)                   DONNACH1  68 RVUE    PHASE-SHIFT ANAL  6/68
M    3     (1640.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
M    3     (1635.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
     3   WHERE MAX. ABSORPTION IS -DONNACH1, 2  ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M    4     (1617.0)                   DAVIES    68 RVUE    P-S ANAL  SOL A   8/69*
M    5     (1623.0)                   DAVIES    68 RVUE    P-S ANAL  SOL B   8/69*
     5   SOL B IS.E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------   82  N*3/2(1650) WIDTH (MEV)   -----------------------

W    1      (250.0)                   BAREYRE   68 RVUE                     11/67
W    2      (130.0)                   BAREYRE   68 RVUE                     11/67
W    3      (177.0)                   DONNACH1  68 RVUE                      6/68
W    3      (177.)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
W    3      (180.)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
W    4      (141.0)                   DAVIES    68 RVUE    P-S ANAL  SOL A   8/69*
W    5      (140.0)                   DAVIES    68 RVUE    P-S ANAL  SOL B   8/69*
       SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------   82  N*3/2(1650) PARTIAL DECAY MODES   ---------------

                                                        DECAY MASSES
P1         N*3/2(1650) INTO PI N                      139+ 938
P2         N*3/2(1650) INTO N PI PI                   938+ 139+ 139

----------------   82  N*3/2(1650) BRANCHING RATIOS   ------------------

R1         N*3/2(1650) INTO (PI N)/TOTAL                (P1)/TOTAL
R1   3      (0.284)                   DONNACH1  68 RVUE                      6/68
R1   3       (.28)                    DONNACH2  68 RVUE    PHAS.SHIFT-CERN1 10/69*
R1   3       (.28)                    KIRSOPP   68 RVUE    PHASE SHIFT ANAL 10/69*
R1   4      (0.28)                    DAVIES    68 RVUE    P-S ANAL  SOL A   8/69*
R1   5      (0.25)                    DAVIES    68 RVUE    P-S ANAL  SOL B   8/69*

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                           REFERENCES -- N*3/2(1650)

DEVLIN   65 PRL 14 1031        T J DEVLIN,J SOLOMON,G BERTSCH  (PRINCETON) I
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK            (GLAS)
DAVIES   68 VIENNA CONF.       A DAVIES,R MOORHOUSE                    (GLAS)
KIRSOPP  68 THESIS             R G KIRSOPP                             (EDIN)

                     PAPERS NOT REFERRED TO IN DATA CARDS.

CARRUTHE 60 PRL 4 303          P CARRUTHERS                        (CORNELL) I
DEVLIN   62 PR 125 69C         T J DEVLIN, B J MOYER, V PEREZ-MENDEZ (LRL) I
HELLAND  64 PR 134 B1062       +DEVLIN,HAGGE,LONGO,MOYER,WOOD          (LRL) I
BAREYRE  65 PL 18 342          + BRICMAN, STIRLING, VILLET        (SACLAY)IJP
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                              (LRL)

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Data in parentheses have not been included in our averages.

Δ(1670) D₃₃

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10  N*3/2(1670, JP=3/2-) I=3/2
FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  10  N*3/2(1670) MASS (MEV)  ------------------------

M  3   (1691.0)              DONNACH1  68 RVUE  PHASE-SHIFT ANAL   8/69*
M  3   (1690.)               DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
M  3   (1690.)               KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
   3  WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M  4   (1649.0)              DAVIES    68 RVUE  P-S ANAL  SOL A    8/69*
M  5   (1650.0)              DAVIES    68 RVUE  P-S ANAL  SOL B    8/69*
   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------  10  N*3/2(1670) WIDTH (MEV)  -----------------------

W  3   (269.0)               DONNACH1  68 RVUE                     8/69*
W  3   (269.)                DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
W  3   (300.)                KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
W  4   (188.0)               DAVIES    68 RVUE             SOL A   8/69*
W  5   (174.0)               DAVIES    68 RVUE             SOL B   8/69*
      SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.P EY

----------------  10  N*3/2(1670) PARTIAL DECAY MODES  ---------------

                                              DECAY MASSES
P1      N*3/2(1670) INTO  PI N                139+ 938
P2      N*3/2(1670) INTO N PI PI              938+ 139+ 139

----------------  10  N*3/2(1670) BRANCHING RATIOS  ------------------

R1      N*3/2(1670) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1  3     (0.14)             DONNACH1  68 RVUE                     8/69*
R1  3     (.14)              DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
R1  3     (.13)              KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
R1  4     (0.12)             DAVIES    68 RVUE             SOL A   8/69*
R1  5     (0.13)             DAVIES    68 RVUE             SOL B   8/69*

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                   REFERENCES -- N*3/2(1670)

DAVIES   68 VIENNA CONF.    A DAVIES,R MOORHOUSE                     (GLAS)
DONNACH1 68 PL 26B 161      A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139      DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP  68 THESIS          R G KIRSOPP                              (EDIN)

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Δ(1690) P″₃₃

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19  N*3/2(1690,JP=3/2+) I=3/2
FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  19  N*3/2(1690) MASS  (MEV)  -----------------------

M  3   (1690.)               DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
M  3   (1690.)               KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
   3  WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69*

----------------  19  N*3/2(1690) WIDTH (MEV)  -----------------------

W  3   (281.)                DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
W  3   (240.)                KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*

----------------  19  N*3/2(1690) PARTIAL DECAY MODES  ---------------

                                              DECAY MASSES
P1      N*3/2(1690) INTO PI N                 139+ 938

----------------  19  N*3/2(1690) BRANCHING RATIOS  ------------------

R1      N*3/2(1690) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1  3     (.10)              DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
R1  3     (.08)              KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*

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                   REFERENCES -- N*3/2(1690)

DONNACH2 68 VIENNA 139      DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP  68 THESIS          R G KIRSOPP                              (EDIN)

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Δ(1890) F₃₅

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11  N*3/2(1890, JP=5/2+) I=3/2
FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  11  N*3/2(1890) MASS (MEV)  ------------------------

M  3   (1913.0)              DONNACH1  68 RVUE  PHASE-SHIFT ANAL   8/69*
M  3   (1910.)               DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
M  3   (1910.)               KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
   3  WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M  4   (1841.0)              DAVIES    68 RVUE  P-S ANAL  SOL A    8/69*
M  5   (1852.0)              DAVIES    68 RVUE  P-S ANAL  SOL B    8/69*
   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------  11  N*3/2(1890) WIDTH (MEV)  -----------------------

W  3   (350.0)               DONNACH1  68 RVUE                     8/69*
W  3   (350.)                DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
W  3   (380.)                KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
W  4   (136.0)               DAVIES    68 RVUE             SOL A   8/69*
W  5   (150.0)               DAVIES    68 RVUE             SOL B   8/69*
       SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

----------------  11  N*3/2(1890) PARTIAL DECAY MODES  ---------------

                                              DECAY MASSES
P1      N*3/2(1890) INTO  PI N                139+ 938
P2      N*3/2(1890) INTO N PI PI              938+ 139+ 139

----------------  11  N*3/2(1890) BRANCHING RATIOS  ------------------

R1      N*3/2(1890) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1  3     (0.16)             DONNACH1  68 RVUE                     8/69*
R1  3     (.16)              DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
R1  3     (.15)              KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
R1  4     (0.20)             DAVIES    68 RVUE             SOL A   8/69*
R1  5     (0.19)             DAVIES    68 RVUE             SOL B   8/69*

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                   REFERENCES -- N*3/2(1890)

DAVIES   68 VIENNA CONF.    A DAVIES,R MOORHOUSE                     (GLAS)
DONNACH1 68 PL 26B 161      A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139      DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP  68 THESIS          R G KIRSOPP                              (EDIN)

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Δ(1910) P₃₁

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12  N*3/2(1910, JP=1/2+) I=3/2
FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  12  N*3/2(1910) MASS (MEV)  ------------------------

M  3   (1934.0)              DONNACH1  68 RVUE  PHASE-SHIFT ANAL   8/69*
M  3   (1930.)               DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
M  3   (1930.)               KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
   3  WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M  4   (1914.0)              DAVIES    68 RVUE  P-S ANAL  SOL A    8/69*
M  5   (1834.0)              DAVIES    68 RVUE  P-S ANAL  SOL B    8/69*
   5  SOL B IS E.D FIT TO SAME DATA START FROM CERN I EXPER. (DONNACH1 68)

----------------  12  N*3/2(1910) WIDTH (MEV)  -----------------------

W  3   (339.0)               DONNACH1  68 RVUE                     8/69*
W  3   (339.)                DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
W  3   (425.)                KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
W  4   (290.)                DAVIES    68 RVUE             SOL A   8/69*
W  5   (231.0)               DAVIES    68 RVUE             SOL B   8/69*
       SEE NOTES ACCOMPANYING MASSES QUOTED AS FOR N*1/2(1910)

----------------  12  N*3/2(1910) PARTIAL DECAY MODES  ---------------

                                              DECAY MASSES
P1      N*3/2(1910) INTO  PI N                139+ 938
P2      N*3/2(1910) INTO N PI PI              938+ 139+ 139

----------------  12  N*3/2(1910) BRANCHING RATIOS  ------------------

R1      N*3/2(1910) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1  3     (0.30)             DONNACH1  68 RVUE                     8/69*
R1  3     (.30)              DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
R1  3     (.25)              KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
R1  4     (0.18)             DAVIES    68 RVUE             SOL A   8/69*
R1  5     (0.24)             DAVIES    68 RVUE             SOL B   8/69*

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                   REFERENCES -- N*3/2(1910)

DAVIES   68 VIENNA CONF.    A DAVIES,R MOORHOUSE                     (GLAS)
DONNACH1 68 PL 26B 161      A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139      DONNACHIE  RAPPORTEUR.S TALK             (GLAS)
KIRSOPP  68 THESIS          R G KIRSOPP                              (EDIN)

             PAPERS NOT REFERRED TO IN THE DATA CARDS

CARYANN  65 PR 138 B433     CARAYANNOPOULOS,TAUTFEST,WILLMANN    (PURD)
    ---    A PARTIAL WAVE ANALYSIS OF PI+P TO SIGMA+ K+

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Δ(1950) F₃₇

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83  N*3/2(1950, JP=7/2+) I=3/2
FOR DISCUSSION CONCERNING RESCNANT PARAMETERS,SEE NOTE
PRECEDING N*3/2(1236).

----------------  83  N*3/2(1950) MASS (MEV)  ------------------------

M      (1920.0)              DUKE      65 CNTR  PI-P EL + POL      6/68
M      (1950.0)    APPROX    YOKOSAWA  66 CNTR  PI- P DSIG + POL   7/66
M  1   (1975.0)              BAREYRE   68 RVUE  PHASE-SHIFT ANAL  11/67
   1            WHERE CROSS SECTION IS GREATEST - EYEBALL FIT
M  2   (1980.0)              BAREYRE   68 RVUE  PHASE-SHIFT ANAL  11/67
   2            WHERE SPEED IS GREATEST - EYEBALL FIT
M  3   (1946.0)              DONNACH1  68 RVUE  PHASE-SHIFT ANAL   6/68
M  3   (1950.)               DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
M  3   (1946.)               KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
   3  WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69*
M  4   (1935.0)              DAVIES    68 RVUE  P-S ANAL  SOL A    8/69*
M  5   (1935.0)              DAVIES    68 RVUE  P-S ANAL  SOL B    8/69*
   5    SOL B IS A FIT TO DONNACHIE 68 SOLUTION

----------------  83  N*3/2(1950) WIDTH (MEV)  -----------------------

W      (170.0)               DUKE      65 CNTR                     7/66
W      (200.0)     APPROX    YOKOSAWA  66 CNTR                     7/66
W  1   (180.0)               BAREYRE   68 RVUE                    11/67
W  2   (140.0)               BAREYRE   68 RVUE                    11/67
W  3   (221.0)               DONNACH1  68 RVUE                     6/68
W  3   (221.)                DONNACH2  68 RVUE  PHAS.SHIFT-CERN1  10/69*
W  3   (220.)                KIRSOPP   68 RVUE  PHASE SHIFT ANAL  10/69*
W  4   (221.0)               DAVIES    68 RVUE             SOL A   8/69*
W  5   (212.0)               DAVIES    68 RVUE             SOL B   8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

----------------  83  N*3/2(1950) PARTIAL DECAY MODES  ---------------

                                              DECAY MASSES
P1      N*3/2(1950) INTO PI N                 139+ 938
P2      N*3/2(1950) INTO SIGMA K              1189+ 493
P3      N*3/2(1950) INTO N*3/2(1236) PI       1236+ 139
P4      N*3/2(1950) INTO Y*1(1385) K          1385+ 493
P5      N*3/2(1950) INTO N*3/2(1236) RHO      1236+ 765
P6      N*3/2(1950) INTO NEUTRON PI+ PI+       939+ 139+ 139
P7      N*3/2(1950) INTO N*3/2(1236) PI PI (NOT RHO)  1236+ 139+ 139
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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-----------------  83  N*3/2(1950) BRANCHING RATIOS   ------------------

R1        N*3/2(1950) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1           (0.41)                   DUKE      65 CNTR   VERY ENERGY DEP   7/66
R1           (0.4)        APPROX      YOKOSAWA  66 CNTR                     7/66
R1  1        (0.57)                   BAREYRE   68 RVUE                    11/67
R1  3        (0.386)                  DONNACH1  68 RVUE                     6/68
R1  3         (.39)                   DONNACH2  68 RVUE   PHAS.SHIFT-CERN1 10/69*
R1  3         (.39)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
R1  4        (0.51)                   DAVIES    68 RVUE              SOL A  8/69*
R1  5        (0.39)                   DAVIES    68 RVUE              SOL B  8/69*
     SEE THE NOTES ACCOMPANYING THE MASSES QUOTED.

R2        N*3/2(1950) INTO (SIGMA K)*(PI N)/TOTAL**2   (P2*P1)/TOTAL**2
R2           SEEN                     BORREANI  68 HBC     PI+P 1.35-1.68  10/69*

R3        N*3/2(1950) INTO (D(1236) PI)*(PIN)/TOTAL**2 (P3*P1)/TOTAL**2
R3          0.23      0.04            FUNG      68 HBC  ++ PI+P TO PI+PIO P 11/68

    MORE INFORMATIONS ON INELASTIC DECAY MODES OF BUMPS, SEEN IN PRODUCTION
    EXPERIMENTS AROUND 1950 MEV, MAY BE FOUND IN THE NEXT ENTRY

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                          REFERENCES -- N*3/2(1950)

DUKE     65 PRL 15 468         +JONES,KEMP,MURPHY,PRENTICE, +  (RTHFD,OXF)IJP
YOKOSAWA 66 PRL 16 714         +SUWA, HILL, ESTERLING, BOOTH     (ARG,CHI)IJP
BAREYRE  68 PR 165 1731        P BAREYRE, C BRICMAN, G VILLET     (SACLAY)IJP
BORREANI 68 UCRL 18350          BORREANI,KALMUS                       (LRL)
DAVIES   68 VIENNA CONF.       A DAVIES,R MOORHOUSE                  (GLAS)
DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
DONNACH2 68 VIENNA 139         DONNACHIE  RAPPORTEUR.S TALK          (GLAS)
FUNG     68 VIENNA CONF.       FUNG, KERNAN, KALMUS, BIRGE (RIVERSIDE,LRL)
KIRSOPP  68 THESIS             R G KIRSOPP                           (EDIN)

                   PAPERS NOT REFERRED TO IN DATA CARDS.

LAYSON   63 NC 27 724          W M LAYSON                          (CERN) IJ
HOHLER   63 NP 48 470          G HOHLER, G EBEL                (KARLSRUHE) I
AUVIL    64 NC 33 473          P AUVIL, C LOVELACE               (IMPCOL)IJP
HOHLER   64 PL 12 149          G HOHLER, J GIESECKE            (KARLSRUHE) I
HELLAND  64 PR 134 B1062       +DEVLIN,HAGGE,LONGO,MOYER,WOOD       (LRL) IJ
HOLLADAY 65 PR 139 B1348       W G HOLLADAY                   (VANDERBILT)
JOHNSON  67 UCRL-17683 THESIS C H JOHNSON                            (LRL)

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Δ(1960) **D_{35}**

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                 13  N*3/2(1960, JP=5/2-) I=3/2

                 FOR DISCUSSION CONCERNING RESONANT PARAMETERS,SEE NOTE
                 PRECEDING N*3/2(1236).

-----------------  13  N*3/2(1960) MASS (MEV)   -----------------------

M   3     (1954.0)                  DONNACH1  68 RVUE   PHASE-SHIFT ANAL  6/68
M   3     (1970.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*
M         (1950.0)        APPROX    LEA       69 CNTR   PI-P ELASTIC      8/69*
    3  WHERE MAX. ABSORPTION IS -DONNACH1, 2 ,KIRSOPP EYEBALL FIT CERN 1  10/69*

-----------------  13  N*3/2(1960) WIDTH (MEV)  -----------------------

W   3     (311.00)                  DONNACH1  68 RVUE                     8/69*
W   3     (400.)                    KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*

-----------------  13  N*3/2(1960) PARTIAL DECAY MODES   ---------------

                                                         DECAY MASSES
P1        N*3/2(1960) INTO PI N                         139+ 938

-----------------  13  N*3/2(1960) BRANCHING RATIOS   ------------------

R1        N*3/2(1960) INTO (PI N)/ TOTAL               (P1)/TOTAL
R1  3       (.154)                  DONNACH1  68 RVUE   PHASE SHIFT ANA. 10/69*
R1  3       (.12)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*

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                          REFERENCES -- N*3/2(1960)

DONNACH1 68 PL 26B 161         A DONNACHIE, R G KIRSOPP, C LOVELACE (CERN)IJP
KIRSOPP  68 THESIS             R G KIRSOPP                           (EDIN)
LEA      69 PL 29B 584         LEA,OADES,WARD,COWAN,+  (RHEL,BRISTOL,DAR)

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1950 MEV REGION – PRODUCTION AND σ_{TOTAL} EXPERIMENTS

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                 70  N* (1950)                           PROD. EXP.

-----------------  70  N* (1950)   MASS (MEV)   -----------------------

M         (1922.0)        APPROX     COOL      56 CNTR   PI+ P TOTAL        7/66
M         (1912.0)  (15.0)           BRISSON   61 CNTR   PI+ P TOTAL        7/66
M         (1900.0)   (9.0)           DEVLIN    65 CNTR   PI+ P TOTAL
M   N     (2080.0)  (12.0)           YOON      67 HBC +  3 BEV/C PI-P       8/67
    N     THIS BUMP IS NOT SEEN BY CHUNG 68 AT 3.2 GEV/C

-----------------  70  N* (1950)   WIDTH (MEV)  -----------------------

W         (256.0)   (39.0)           DEVLIN    65 CNTR
W           40.0     20.0            YOON      67 HBC +                     8/67

-----------------  70  N* (1950)   BRANCHING RATIOS   ----------------

R1        N*   (1950) INTO (PI N)/TOTAL                  PROD. EXP.
R1          (0.57)  (0.12)           DEVLIN    65 CNTR

R2        N*   (1950) INTO (SIGMA K)/(PI N)              PROD. EXP.
R2          0.059    0.024           CHINOWSKY 68 HBC ++ PP TO P SIG K     11/68

R3        N*   (1950) INTO N*3/2(1236) PI PI (NOT RHO)
R3            SEEN                   CHINOWSKY 68 HBC ++ PP TO (P 3PI) N  11/68

R4        N*   (1950) INTO (PI N)/(N*3/2(1236) PI)       PROD. EXP.
R4          LESS THAN 0.55           LEE       67 HBC    PI-P 3.63 BEV/C  11/67

R5    N*  (1950) INTO ((PI N)*(NEUTRON PI+ PI+))/TOTAL   PROD. EXP.
R5          0.05     0.013           GALLOWAY  68 RVUE ++ PI+P TO N 2PI+   6/68

R6        N*   (1950) INTO (Y*1(1385) K)/(PI N)          PROD. EXP.
R6          0.035    0.015           CHINOWSKY 68 HBC ++ PP TO P LAM K PI 11/68

R7        N*   (1950) INTO (N*3/2(1236) RHO)/(PI N)      PROD. EXP.
R7           (0.45)    APPROX        CHINOWSKY 68 HBC ++ PP TO (P 3PI) N  11/68
        THIS INCLUDES CORRECTION FOR UNSEEN DECAY (ISPIN FACTOR 5/3).

R8        N*   (1950) INTO (N*3/2(1236) RHO)/TOTAL
R8            SEEN                   YOON      67 HBC +                     8/67

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                     REFERENCES -- N* IN PRODUCT EXPERIMENTS

COOL     56 PR 103 1082        R COOL, O PICCIONI, D CLARK             (BNL) I
BRISSON  61 NC 19 210          +DETOEUF,FALK-VAIRANT,VAN ROSSUM,+ (SACLAY) I
DEVLIN   65 PRL 14 1031        T J DEVLIN,J SOLOMON,G BERTSCH  (PRINCETON) I
LEE      67 PR 159 1156        +MOEBS,ROE,SINCLAIR,VANDER VELDE       (MICH)
YOON     67 PL 24B 307         +BERENYI,KEY,PRENTICE, +      (TORONTO,WISC)

CHINOWSK 68 PR 171 1421        CHINOWSKY,CONDON,KINSEY,KLEIN,+  (LRL,SLAC)
CHUNG    68 PR 165 1491        S U CHUNG,DAHL,KIRZ,MILLER              (LRL)
GALLOWAY 68 PL 26B 334         K F GALLOWAY                       (INDIANA) I

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                     END PRODUCTION EXPERIMENTS

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Δ(2160) **P'''_{33}**

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                 9  N*3/2(2160,JP=3/2+) I=3/2

                 SEE THE NOTES PRECEDING N*3/2(1236)

-----------------  9  N*3/2(2160) MASS  (MEV)   -----------------------

M   3     (2160.)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*

-----------------  9  N*3/2(2160) WIDTH (MEV)   -----------------------

W   3     (260.)                    KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*

-----------------  9  N*3/2(2160) PARTIAL DECAY MODES   ----------------

                                                         DECAY MASSES
P1        N*3/2(2160) INTO PI N                         139+ 938

-----------------  9  N*3/2(2160) BRANCHING RATIOS   ------------------

R1        N*3/2(2160) INTO (PI N)/TOTAL                 (P1)/TOTAL
R1  3       (.25)                   KIRSOPP   68 RVUE   PHASE SHIFT ANAL 10/69*

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                          REFERENCES -- N*3/2(2160)

KIRSOPP  68 THESIS             R G KIRSOPP                           (EDIN)

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M > 2200 MEV – PRODUCTION AND σ_{TOTAL} EXPERIMENTS.

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Δ(2420)

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                 84  N*3/2(2420, JP=11/2+) I=3/2

                  PARTIAL WAVE ANALYSIS OF BELLAMY 67 SUGGESTS J=11/2

-----------------  84  N*3/2(2420) MASS (MEV)   -----------------------

M         (2360.0)                  DIDDENS   63 CNTR   PI+ P TOTAL
M         (2520.0)  (40.0)          ALVAREZ   64 CNTR   PI PHOTOPROD       7/66
M         (2400.0)        APPROX    WAHLIG    64 OSPK 0 PI-P CH EX
M         (2440.0)                  HOHLER    64 RVUE   DATA + DISP REL
M          2423.0    10.0           CITRON    66 CNTR   PI+ P TOTAL        7/66
M   B     (2452.0)                  BARGER    66 RVUE   TOTAL + CH EX     11/67
    B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
    B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.

-----------------  84  N*3/2(2420) WIDTH (MEV)  -----------------------

W         (200.0)                   DIDDENS   63 CNTR
W         (245.0)                   HOHLER    64 RVUE                      7/66
W          310.0     20.0           CITRON    66 CNTR                      7/66
W   B     (275.0)                   BARGER    66 RVUE   TOTAL + CH EX     11/67

-----------------  84  N*3/2(2420) PARTIAL DECAY MODES   ---------------

                                                         DECAY MASSES
P1        N*3/2(2420) INTO PI N                         139+ 938
P2        N*3/2(2420) INTO SIGMA K                     1197+ 493
P3        N*3/2(2420) INTO N*3/2(1236) PI              1236+ 139
P4        N*3/2(2420) INTO NEUTRON PI+ PI+              939+ 139+ 139

-----------------  84  N*3/2(2420) BRANCHING RATIOS   ------------------

R1        N*3/2(2420) INTO (PI N)/TOTAL                (P1)/TOTAL
R1          (0.067)      APPROX     DIDDENS   63 CNTR   ASSUMING J=11/2    7/66
R1           0.113    0.0036        CITRON    66 CNTR   ASSUMING J=11/2    7/66
R1  B       (0.12)                  BARGER    67 FIT    ASSUMING J=11/2   11/67
R1  D       (0.163)                 DIKMEN    67 FIT    ASSUMING J=11/2   11/67
    D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1          (0.06)                  KORMANYOS 67 CNTR   ASSUMING J=11/2   11/67

R2  N*3/2(2420) INTO (PI N)*(NEUTRON PI+ PI+)/(TOTAL**2) (P1*P4)/TOTAL**2
R2           0.0195   0.0048        GALLOWAY  68 RVUE                      6/68

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                          REFERENCES -- N*3/2(2420)

DIDDENS  63 PRL 10 262         +JENKINS, KYCIA, RILEY                  (BNL) I
ALVAREZ  64 PRL 12 710         +BAR-YAM,KERN,LUCKEY,OSBORNE, +   (MIT,CEA)
WAHLIG   64 PRL 13 103         +MANNELLI,SODICKSON,FACKLER,WARD, +   (MIT)
HOHLER   64 PL 12 149          G HOHLER, J GIESECKE             (KARLSRUHE) I
CITRON   66 PR 144 1101        +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER   66 PR 151 1123        V BARGER, M OLSSON                     (WISC)

BARGER   67 PR 155 1792        V BARGER, D CLINE                      (WISC) P
DIKMEN   67 PRL 18 798         F N DIKMEN                             (MICH)
KORMANYO 67 PR 164 1661        KORMANYOS, KRISCH, OFALLON, +     (MICH,ARG) P
DOLEN    68 PR 166 1768        R DOLEN, D HORN, C SCHMID          (CAL TECH)
GALLOWAY 68 PL 26B 334         K F GALLOWAY                       (INDIANA) I
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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                   PAPERS NOT REFERRED TO IN DATA CARDS.

DOBROWOL 67 PL 24B 203       DOBROWOLSKI,GUSKOV,LIKHACHEV, +      (DUBNA) P
BELLAMY  67 PRL 19 476       +BUCKLEY,DOBINSON, +      (WESTFIELD,UNICOL) JP
BAACKE   67 NC 51A 761       J BAACKE, M YVERT         (KARLSRUHE,ORSAY)J-L
WAHLIG   68 PR 168 1515      M A WAHLIG, I MANNELLI              (MIT,PISA)
      --  FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
          CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
          COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

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Δ(2850)

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                 85  N*3/2(2850, JP=    +) I=3/2
---------------- 85  N*3/2(2850) MASS (MEV)   -------------------------

M        (2700.0)        APPROX       WAHLIG    64 OSPK 0  PI-P CH EX
M        (2870.0)                     HOHLER    64 RVUE    DATA + DISP REL
M         2850.0    12.0              CITRON    66 CNTR    PI+ P TOTAL      7/66
M        (2850.0)                     BARDADIN  66 HBC  ++ N* TO P + 3 PIS  7/66

---------------- 85  N*3/2(2850) WIDTH (MEV)  -------------------------

W          400.0    40.0              CITRON    66 CNTR                     7/66
W        (150.0)                      BARDADIN  66 HBC  ++                  7/66

---------------- 85  N*3/2(2850) PARTIAL DECAY MODES   ----------------

                                                     DECAY MASSES
P1       N*3/2(2850) INTO PI N                      139+ 938
P2       N*3/2(2850) INTO P PI PI PI                938+ 139+ 139+ 139
P3       N*3/2(2850) INTO N PI PI                   938+ 139+ 139

---------------- 85  N*3/2(2850) BRANCHING RATIOS    ------------------

R1       N*3/2(2850) INTO (PI N)/TOTAL                (P1)/TOTAL
R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1           0.261    0.048           CITRON    66 CNTR    TOTAL CROSS.SEC. 11/67
R1  B       (0.224)  (0.016)          BARGER    66 RVUE    TOTAL + CH EXC.  11/67
R1  B       (0.40)                    BARGER    67 RVUE    USES KORMANYOS66 11/67
    B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
    B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D       (0.49)                    DIKMEN    67 RVUE    USES KORMANYOS67 11/67
    D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES
R1          (0.10)                    KORMANYOS 67 CNTR    PI-P AT 180 DEG. 11/67
R1          (0.39)                    DOBROWOLS 67 CNTR    PI+P AT 180 DEG

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                        REFERENCES -- N*3/2(2850)

WAHLIG   64 PRL 13 103       +MANNELLI,SODICKSON,FACKLER,WARD, +   (MIT)
HOHLER   64 PL 12 149        G HOHLER, J GIESECKE           (KARLSRUHE) I
CITRON   66 PR 144 1101      +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARDADIN 66 PL 21 357        BARDADIN-OTWINOWSKA,DANYSZ, +      (WARSAW)
BARGER   66 PR 151 1123      V BARGER, M OLSSON                   (WISC)

BARGER   67 PR 155 1792      ' BARGER, D CLINE                    (WISC) P
DIKMEN   67 PRL 18 798       F N DIKMEN                           (MICH)
DOBROWOL 67 PL 24B 203       DOBROWOLSKI,GUSKOV,LIKHACHEV, +     (DUBNA) P
KORMANYO 67 PR 164 1661      KORMANYOS, KRISCH, OFALLON, +    (MICH,ARG) P
DOLEN    68 PR 166 1768      R DOLEN, D HORN, C SCHMID         (CAL TECH)

                   PAPERS NOT REFERRED TO IN DATA CARDS.

BAACKE   67 NC 51A 761       J BAACKE, M YVERT         (KARLSRUHE,ORSAY)J-L
WAHLIG   68 PR 168 1515      M A WAHLIG, I MANNELLI              (MIT,PISA)
      --  FINAL VERSION OF DATA USED IN WAHLIG 64.  IN CONJUNCTION WITH
          CITRON 66 TOTAL CROSS SECTIONS, THIS CHARGE EXCHANGE DATA GIVES
          COMPLEX ELASTIC SCATTERING AMPLITUDE AT 0 DEGREES.

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Δ(3230)

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                 86  N*3/2(3230, JP=     ) I=3/2
---------------- 86  N*3/2(3230) MASS (MEV)   -------------------------

M        (3230.0)                     CITRON    66 CNTR    PI+ P TOTAL      7/66

---------------- 86  N*3/2(3230) WIDTH (MEV)  -------------------------

W        (440.0)                      CITRON    66 CNTR                     7/66

---------------- 86  N*3/2(3230) PARTIAL DECAY MODES   ----------------

                                                     DECAY MASSES
P1       N*3/2(3230) INTO PI N                      139+ 938
P2       N*3/2(3230) INTO N PI PI                   938+ 139+ 139

---------------- 86  N*3/2(3230) BRANCHING RATIOS    ------------------

R1    ONLY (J+1/2)*( PI N/TOTAL) MEASURED FOR THIS STATE
R1          (0.06)                    CITRON    66 CNTR    TOTAL CROS. SEC. 11/67
R1  B       (0.03)   (0.01)           BARGER    66 RVUE    TOTAL + CH EXC.  11/67
R1  B       (0.03)  TO  0.1           BARGER    67 CNTR    USES KORMANYOS66 11/67
R1  B  USES REGGE AMP.+RESON. TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGRE
R2  B  FOR CRITICISM OF THIS METHOD, SEE DOLEN 68.
R1  D       (0.25)                    DIKMEN    67 RVUE    USES KORMANYOS67 11/67
R1  D  USES ONLY RESONANCES TO CALCULATE DIF. CROSS SECTIONS AT 180 DEGREES

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                        REFERENCES -- N*3/2(3230)

CITRON   66 PR 144 1101      +GALBRAITH,KYCIA,LEONTIC,PHILLIPS, +  (BNL) I
BARGER   66 PR 151 1123      V BARGER, M OLSSON                   (WISC)
BARGER   67 PR 155 1792      V BARGER, D CLINE                    (WISC) P
DIKMEN   67 PRL 18 798       F N DIKMEN                           (MICH)
KCRMANYO 67 PR 164 1661      KORMANYOS, KRISCH, OFALLON, +    (MICH,ARG) P
DOLEN    68 PR 166 1768      R DOLEN, D HORN, C SCHMID         (CAL TECH)

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                        END PRODUCTION EXPERIMENTS

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Note on Possible Z^*'s

Although it is not yet known whether the peaks seen in the total KN cross sections near 1 GeV/c are resonances, considerable progress has been made in the last year in understanding the isospin-1 channel. Since positive-strangeness baryons cannot be made from 3 quarks, it is very important to find out if the peaks are indeed resonances.

Papers that were available a year ago were rather extensively discussed in our last edition (RMP 41, 109 (1969); see pp. 171-3). No new evidence on Z_0^* has been reported in the last year, due to the difficulty of extracting the I = 0 system from the deuterium data. As for the Z_1^*, new experimental results have been reported. Two experiments measuring K^+p elastic-scattering polarization have been published in ASBURY 69 and in two ANDERSSON 69 papers. These results, combined with previously measured total and elastic-scattering cross-section data (ANDERSSON-2 69 also adds new differential cross-section data), make possible phase-shift analyses in which it is not necessary to reduce the number of fitted parameters by constraining the partial waves to have some specific energy dependence. Such analyses are given in ASBURY 69 and ANDERSSON-2 69.

The best solutions found in the two analyses agree with one another in outline but not in detail. The main point for this discussion is that, in each case, in the best solution there is a resonance-like counterclockwise motion of the P13 amplitude. This is shown in the accompanying figure. The figure also shows the speed $|d\vec{T}/dE|$ of the amplitude in the Argand plot for these two analyses (ASBURY 69 and ANDERSSON-2 69) of the elastic data and the $K^0 \Delta^{++}$ reaction amplitude of BLAND 68. The speed algorithm for E_i was

Data in parentheses have not been included in our averages.

$$\left|\frac{d\vec{T}}{dE}\right|_i = \frac{1}{2}\left|\frac{\vec{T}_{i+1} - \vec{T}_i}{E_{i+1} - E_i}\right| + \frac{1}{2}\left|\frac{T_i - T_{i-1}}{E_i - E_{i-1}}\right|$$

except for the upper and lower energies, where an unsymmetrical version must be used.[1] This plot shows a general enhancement of the speed for the elastic channel in the vicinity of 1900 MeV; however, because of the uncertainty on each point in the Argand plot, this evidence should be taken with caution. Note that the elastic scattering partial cross section has no visible structure, but falls off smoothly. As for the inelastic channels, the KNπ cross section shows a rapid rise between 0.9 and 1.2 GeV/c. The largest part of the $K^+p \to KN\pi$ cross section is the quasi-2-body reaction $K^+p \to K\Delta$, which in turn is fed most by the P13 amplitude (BLAND 67 and 68). The speed for KΔ shows a rather unusual behavior. The large value at low energy could be attributed to the threshold behavior, while the large speed near 200 MeV could be associated with a resonance. Thus in both the elastic and inelastic channels, the P13 amplitude is quite firmly established as the candidate for resonance-hood.

An almost certainly correct way to describe the P13 amplitude would be in terms of a coupled-channel threshold effect: The KN amplitude becomes rapidly absorptive as it feeds the rapidly increasing KΔ channel. The main question still remains: Is it also a resonance? If it is, its elasticity is only about 0.25 and it decays mainly to KΔ. But a definite conclusion has yet to be made. To make it may require some more work from experimentalists.

For another discussion, see LEVI SETTI 69.

Reference

1. D. Herndon, A. Barbaro-Galtieri, A. H. Rosenfeld, UCRL-8030 Part II. See this report for the Argand plots and the speed plots of K^+ data.

$Z_0(1865)$

```
96  Z*0(1865, JP=    ) I=0
    SEE THE PRECEDING NOTE.
---------------- 96  Z*0(1865) MASS (MEV)  --------------------------

M         1868.0     10.0          KYCIA     67 CNTR    K+P, D TOTAL       8/67
M         1860.0     15.0          CARTER    67 THEO    DISPERSION REL.    8/67
M          . . . . . . . . .
M   AVG   1865.5      8.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

---------------- 96  Z*0(1865) WIDTH (MEV)  -------------------------

W          160.0     30.0          KYCIA     67 CNTR                       8/67
W          200.0     50.0          CARTER    67 THEO                       8/67
W          . . . . . . . . .
W   AVG    170.6     25.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

---------------- 96  Z*0(1865) PARTIAL DECAY MODES  -----------------

                                                    DECAY MASSES
P1        Z*0(1865) INTO K N                       493+ 939
P2        Z*0(1865) INTO N K*(890)                 938+ 897

---------------- 96  Z*0(1865) BRANCHING RATIOS  --------------------

R1        Z*0(1865) INTO (K N)/TOTAL                (P1)/TOTAL
R1           0.40     0.05         KYCIA     67 CNTR    IF J=1/2           8/67
R1           0.31     0.05         CARTER    67 THEO    IF J=1/2           8/67
R1         . . . . . . . . . .
R1  AVG      0.355    0.045   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

R2        Z*0(1865) INTO N K*(890)                  (P2)
R2           MAIN INELASTIC DECAY   HIRATA    68 HBC                      11/68

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                        REFERENCES -- Z*0(1865)

                     SEE REFERENCES FOR THE Z*1(1900)

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$Z_1(1900)$

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97  Z*1(1900, JP=    ) I=1'
    SEE THE NOTE PRECEDING THE Z*0(1865).

---------------- 97  Z*1(1900) MASS (MEV)  --------------------------

M         1900.0     10.0          KYCIA     67 CNTR ++ K+P TCTAL          8/67

---------------- 97  Z*1(1900) WIDTH (MEV)  -------------------------

W          260.0     50.0          KYCIA     67 CNTR ++                    8/67

---------------- 97  Z*1(1900) PARTIAL DECAY MODES  -----------------

                                                    DECAY MASSES
P1        Z*1(1900) INTO K N                       493+ 938
P2        Z*1(1900) INTC N*3/2(1236) K            1236+ 493

---------------- 97  Z*1(1900) BRANCHING RATIOS  --------------------

R1        Z*1(1900) INTO (K N)/TOTAL                (P1)/TOTAL
R1           0.25     0.06         KYCIA     67 CNTR ++ IF J=1/2           8/67
R1          (0.10)      OR LESS    CARTER    67 THEO    DISPERSION REL.    8/67

R2        Z*1(1900) INTO K N*3/2(1236)              (P2)
R2           MAIN INELASTIC DECAY   BLAND     67 HBC ++                    8/67

----------------  Z*1 CROSS SECTION LIMITS (MICROBARNS)  ------------

CS    LESS THAN 50.                BASSOMPIE 68 HBC    K+P TO Z*+ PI+   10/69*
CS  A LESS THAN .2     +.3     -.1  ANDERSON  69 ASPK + PI-P TO K-Z*+    10/69*
CS  A      ABOVE LIMIT FOR  M=1.2 TO 1.4 GEV - CL= 99 P.C.
CS  B LESS THAN 1.4   +1.9     -.5  ANDERSON  69 ASPK + PI-P TO K-Z*+    10/69*
CS  B      ABOVE LIMIT FOR  M=1.5 TO 2.5 GEV

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                        REFERENCES -- Z*1(1900)

     TOTAL-CROSS-SECTION EXPERIMENTS ---
COOL     66 PRL 17 102         +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA    67 PRIVATE COMM.      T F KYCIA                            (BNL) I
ABRAMS   67 PRL 19 259         +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
BUGG     68 PR 168 1466        +GILMORE,KNIGHT, +     (RTHFD,BRMGHM,CVNDSH) I

     DISPERSION-RELATION CALCULATION USING TOTAL-CROSS-SECTION DATA ---
CARTER   67 PRL 18 801         A A CARTER                       (CAVENDISH)
CARTER   68 PREPRINT           A A CARTER                       (CAVENDISH)

     EXPERIMENTS MAINLY ABOUT INELASTIC CHANNELS ---
BLAND    67 PRL 18 1077        +BOWLER,BROWN,G+S GOLDHABER,SEEGER,+  (LRL)
BLAND    68 UCRL-18131 THESIS R W BLAND                             (LRL)
HIRATA   68 PRL 21 1485        HIRATA, WOHL, GOLDHABER, TRILLING     (LRL)
BLAND    69 NP (SUBMITTED)     +BOWLER, BROWN, KADYK, GOLDHABER, +   (LRL)

     A K-MATRIX ANALYSIS OF SOME OF THE EARLY K+P DATA ---
HITE     67 THESIS             G E HITE                          (ILLINOIS)

     THE MAIN K+P ELASTIC SCATTERING AND POLARIZATION EXPERIMENTS ---
CARROLL  68 PRL 21 1282        +FISCHER, LUNDBY, PHILLIPS, +    (BNL,ROCH)
ANDERS-1 69 PL 28B 611         ANDERSSON, DAUM, ERNE, LAGNAUX, +    (CERN)
ASBURY   69 PRL 23 194         +DOWELL, KATO, LUNDQUIST, NOVEY, + (ARG,MD)
BLAND    69 PL 29B 618         R W BLAND, G GOLDHABER, G H TRILLING  (LRL)
BGRT     69  LUND PAPER 26     BOLOGNA ,GLASGOW,ROME,TRIESTE COLLABORAT.

ANDERS-2 69 PL 30B 56          ANDERSSON, DAUM, ERNE, LAGNAUX, +    (CERN)

     THE MAIN PHASE-SHIFT ANALYSES ARE ASBURY 69 AND ANDERSSON-2 69, LISTED
     ABOVE.  THE FOLLOWING ANALYSES DONT INCLUDE THE POLARIZATION DATA GIVEN
     IN THOSE TWO PAPERS ---
LEA      68 PR 165 1770        LEA, MARTIN, OADES           (RTHFD,BNL,CERN)
MARTIN   68 PRL 21 1286        B R MARTIN                            (BNL)
HALL     69 UCRL-19231         HALL, BLAND, GOLDHABER, TRILLING      (LRL)
LEA      69  LUND PAPER 362    LEA,MARTIN,OADES                  (RHEL+UCL)

     PRODUCTION EXPERIMENTS THAT LOOK FOR A Z* ---
TYSON    67 PRL 19 255         +GREENBERG,HUGHES,LU,MINEHART,MORI,  (YALE)
MORI     68 PL 28B 152         +GREENBERG,HUGHES,LU,ROTHBERG, +     (YALE)
BASSOMPI 68 PL 27B 468         BASSOMPIERRE, +              (CERN,BRUXELLES)
ANDERSON 69 PL 29B 136         +BLESER, BLIEDEN, COLLINS, + (BNL,CARNEGIE)
     --  ANDERSON 69 REPLACES WHAT WAS PREVICUSLY LISTED AS BIRNBAUM 67.

     LATEST RELEVANT RAPPORTEUR TALK ---
LEVISETT 69 LUND CONF          R LEVI SETTI  (RAPPORTEUR)        (CHICAGO)

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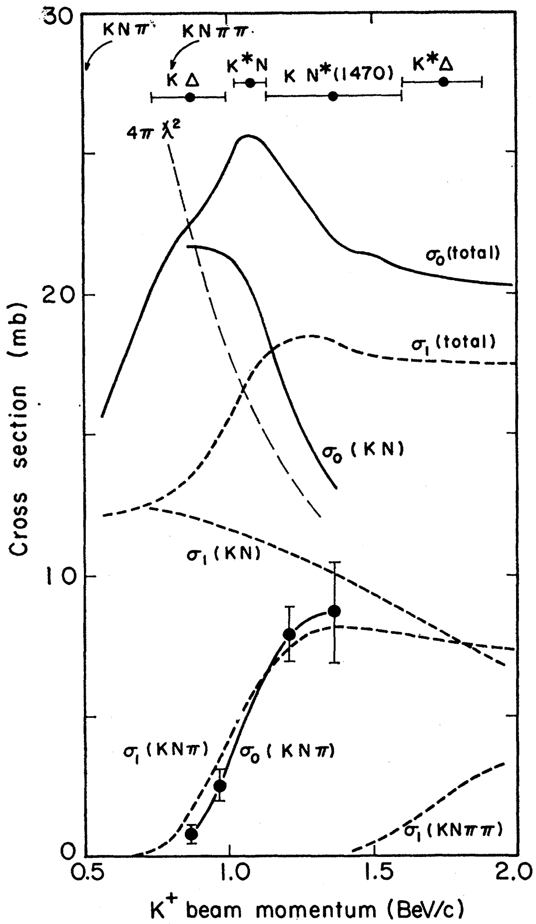
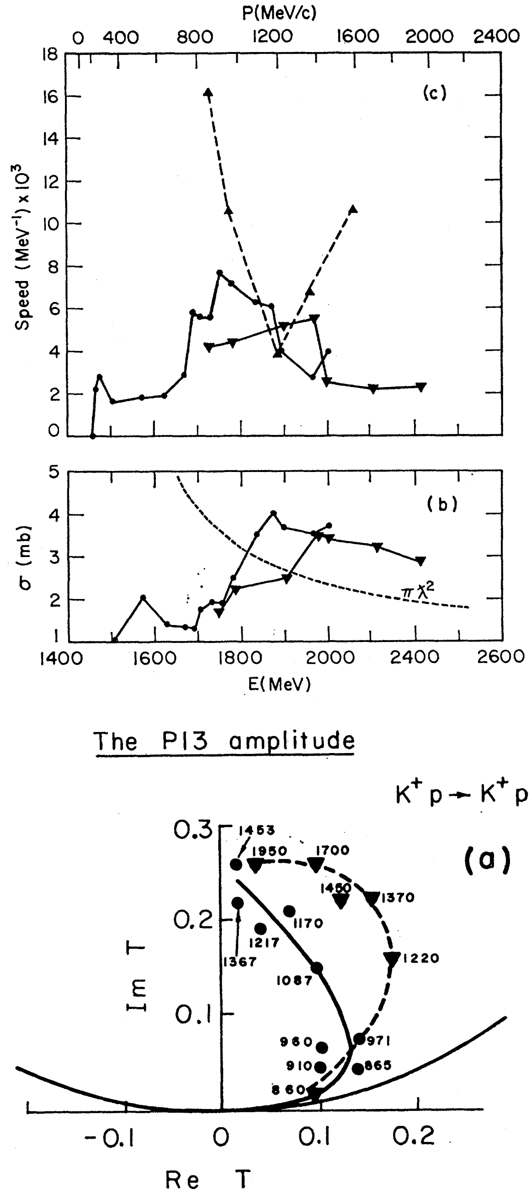
See the illustrated key preceding the data card listings.



XBL 6912-6665

KN total and partial cross sections. Subscripts indicate isospin. Total cross sections are from CARTER 68, which uses data from COOL 66 and BUGG 68. Isospin-1 partial cross sections are adapted from a compilation made by BLAND 68. Isospin-0 partial cross sections are from HIRATA 68. Thresholds for various processes are indicated at the top.



XBL 6911-6562

(a) The amplitude for the P13 partial wave of the analyses of ANDERSSON 69 (●) and ASBURY 69 (▼). Incident K^+ moments are indicated for each point.
(b) Total K^+ cross section $\sigma = 4\pi ƛ^2\,[J+(1/2)]$ Im T for the two above experiments.
(c) Speed plot, as explained in the test, for the same two experiments and for the BLAND 67, 68, and 69 experiment (▲).

Note on Y^*'s

The number of known or suspected Y^* states has increased considerably in the last year or two, following closely a similar increase in the number of N^* states.[1] Just as the recently discovered N^*'s are only weakly coupled in the $\pi N \rightarrow \pi N$ reaction, so also are the recently discovered Y^*'s only weakly coupled in the $\overline{K}N \rightarrow \overline{K}N$, $\overline{K}N \rightarrow \Lambda\pi$, and $\overline{K}N \rightarrow \Sigma\pi$ reactions. The older, well-established resonances are usually clearly visible as peaks in cross sections, as characteristic variations of angular distributions of 2-body final states, and (or) as peaks in invariant-mass distributions of subsets of particles in 3-or-more-body final states. Although some of the newer and less-well-established resonances are seen as small peaks in invariant-mass distributions, many of them make no direct appearance at all, often because there are many states at the same mass and it is not clear which ones (or how many) are being observed. Rather when the 2-body reactions are partial-wave analyzed, some of the amplitudes are found to traverse resonance-like counterclockwise circles. Clearly the results of partial-wave analyses give the J^P information, whereas a peak seen in an invariant mass distribution or a total cross section usually cannot be analyzed for its quantum numbers. We will keep information coming from formation experiments and from production experiments separate, whenever necessary.

Formation experiments. Partial-wave analyses have been performed on many channels, mainly $\overline{K}N$, $\Lambda\pi$, $\Sigma\pi$, ΞK. Given the present accuracy of the data it is not possible to perform a completely energy-independent analysis, that is, solve for the partial-wave amplitudes at each energy. Usually many solutions are found and even when it is required that solutions at neighboring energies join smoothly, it is not possible to select a unique overall solution. To overcome this, one specifies the form of the energy dependence of some or all of the partial-wave amplitudes. Analyses in which the energy dependence of all the amplitudes is specified are called energy dependent. Thus an amplitude known to resonate will be given a Breit-Wigner form, whereas an amplitude not a priori known to resonate may be tried alternately with a resonance form and with some simple nonresonant form, the choice between these then being made by comparing the goodness-of-fit parameters for the two fits. Not surprisingly, sometimes neither fit is very good, nor is the choice between them always clear. Errors given on resonance parameters from this kind of analysis tend to be small, for they are usually only the statistical errors and don't reflect the quite possibly large systematic errors that result from the restrictive parameterization forced on the amplitudes.

Analyses in which most of the amplitudes are left unspecified are called (not quite correctly) energy independent. Figure 1 shows results of such an analysis of the reaction $K^-p \rightarrow \Lambda\pi$ by ARMENTEROS 69. The D_{15} amplitude was fixed as the Σ (1765) with resonance parameters obtained from an earlier energy-dependent analysis. This amplitude acts as an analyzer for the other amplitudes, which were allowed to vary freely. The S_{11} and D_{13} amplitudes appear to resonate. Figure 2 shows results of a similar analysis, also by ARMENTEROS 69, of the reaction $K^-p \rightarrow \Sigma\pi$. Here the $D_{13}\Sigma(1660)$, D_{03} $\Lambda(1690)$, $D_{15}\Sigma(1765)$, and $F_{05}\Lambda(1815)$ were fixed. It appears that several of the other amplitudes may resonate too. It should be clear from the figures that it is not always possible to decide whether or not an amplitude resonates. Neither is it possible to determine very accurately the parameters of the amplitudes that do resonate, nor to assign meaningful errors to the parameters. The state

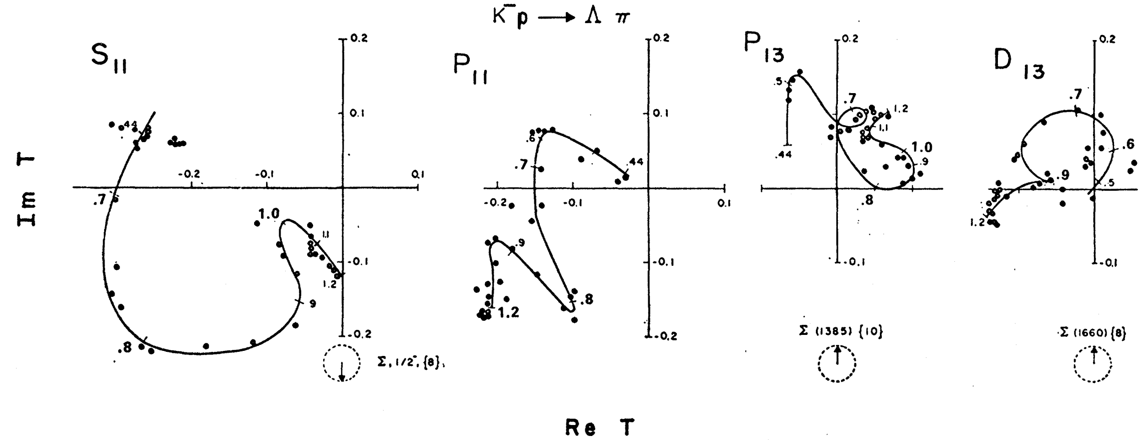


Fig. 1. Partial-wave amplitudes for the reaction $K^-p \to \Lambda\pi$ as determined in the energy-independent analysis of ARMENTEROS 69. The K^- laboratory momenta are indicated. The arrows in a circle, drawn in the lower part of the imaginary axes, fix the sign convention used. See LEVI SETTI 69. Notice that the sign convention used here is different from the one of the Argand plots of our previous edition [RMP 41, 109 (1969)].

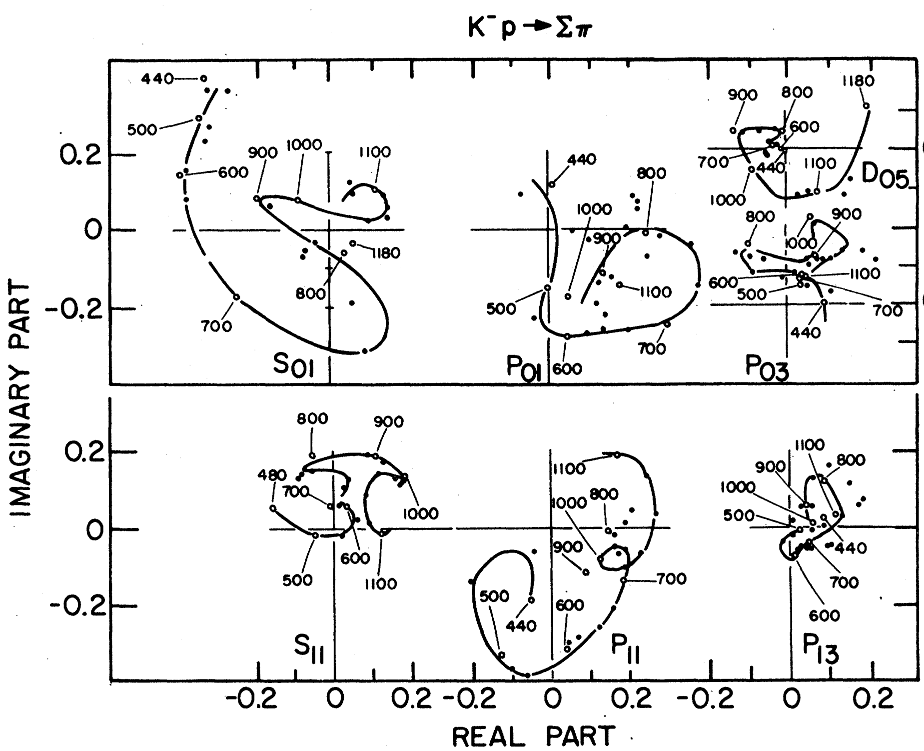


Fig. 2. Partial-wave amplitudes for the reaction $K^-p \to \Sigma\pi$ as determined in the energy-independent analysis of ARMENTEROS 69. The K^- laboratory momenta are indicated. Here again the sign convention follows LEVI SETTI 69.

Data in parentheses have not been included in our averages.

of knowledge of the newer Y^{*}'s is rather more qualitative than quantitative.

Production experiments. These types of experiments are often difficult to analyze. Information on I = 0 states is possible only when there is no I = 1 state at similar mass. The main controversies at the present time lie in the resonances in the 1600- to 1700-MeV region. See note preceding Σ(1620) and Σ(1660) listings for detailed discussions.

Table I is an attempt to evaluate the status of the various Y^{*}'s. The evaluations are of course partly subjective. A blank indicates that there is no corresponding evidence at all. This may mean either that the relevant couplings are small or that the resonance does not really exist. The BARYON TABLE includes only the well-established resonances. It seems clear, however, that whereas any particular one of the questionable resonances may disappear with the next analysis, there definitely are many new resonances underlying those we are more familiar with.

References

1. For a recent review of Y^{*} resonances see R. Levi-Setti, rapporteur talk at the Lund Internation Conference on Particle Physics (Lund, June 1969).

Y* TABLE I. THE PRESENT STATUS OF THE Y* RESONANCES. THOSE WITH AN OVERALL STATUS OF *** OR **** ARE INCLUDED IN THE BARYON TABLE.

PARTICLE	LIJ	OVERALL STATUS	STATUS AS SEEN IN -- TOTAL* CR. SEC.	KBAR N	LAM PI	SIG PI	OTHER CHANNELS
LAM(1330)		*					LAM GAM
LAM(1405)	S01	****			F	****	
LAM(1520)	D03	****	****	****	O	****	LAM 2PI,LAM GA
LAM(1670)	S01	****		***	R	***	LAM ETA
LAM(1680)	P01	**			B	**	
LAM(1690)	D03	****	****	****	I	****	LAM 2PI,SIG 2P
LAM(1800)	P01	**		**	D		
LAM(1815)	F05	****	****	****	D	****	SIG(1385) PI
LAM(1830)	D05	***		**	E	***	
LAM(1860)		**	**	**	N	**	
LAM(2015)	F07	**			F	**	
LAM(2100)	G07	****	****	****	O		
LAM(2350)		****	****		R		
SIG(1385)	P13	****			****	****	
SIG(1440)		*			*		
SIG(1480)		*			*	*	
SIG(1560)	P11	**				**	
SIG(1620)		**			**		LAM 2-PI
SIG(1670)	D13	****	**	**	***	****	SEVERAL OTHERS
SIG(1690)		**	*		**		LAM 2-PI
SIG(1750)	S11	***		**	**		SIG ETA
SIG(1765)	D15	****	****	****	****	**	SEVERAL OTHERS
SIG(1880)	P11	**			**		
SIG(1915)	F15	***	***	**			
SIG(2030)	F17	****	****	****	****		
SIG(2130)	G17	**				**	
SIG(2250)		****	****				
SIG(2455)		***	***				
SIG(2595)		***	***				
SIG(3000)		**					

**** GOOD, CLEAR, AND UNMISTAKABLE.
*** GOOD, BUT FOR ONE REASON OR ANOTHER, NOT CERTAIN.
** NEEDS CONFIRMATION.
* WEAK OR REPUDIATED.
* ATTRIBUTED TO THE RESONANCE CLOSER IN MASS TO WHERE TOT. CR. SEC. PEAKS

Λ

18 LAMBDA (1115,JP=1/2+) I=0

SEE LISTINGS OF STABLE PARTICLES

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Λ(1330)

87 Y*0(1330, JP=) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

A PEAK IS SEEN NEAR 1330 MEV IN THE LAMBDA GAMMA SPECTRUM IN THREE PI- PROPANE EXPERIMENTS (YUNG-CHANG 64, BUBELEV 67, AND BOZOKI 68). IN THE FIRST TWO, THIS WAS TAKEN AS INDIRECT EVIDENCE FOR THE Y*0(1670) DECAYING TO LAMBDA ETA, WITH THE ETA DECAYING TO TWO GAMMAS. IN THE THIRD EXPERIMENT THIS INTERPRETATION HAS BEEN RULED OUT. BOZOKI 68 MENTION THE POSSIBILITY OF THERE BEING A Y*0(1330) WITH A NARROW WIDTH (LT 25 MEV), BUT DEFER SERIOUS CONSIDERATION OF IT UNTIL THERE IS MORE DATA.

SHOULD SUCH A RESCNANCE EXIST, IT SHOULD BE SEEN IN PI- P TO K0 + (MISSING MASS). DAHL 67 FOUND NO EVIDENCE FOR IT.

A SEARCH FOR A NEW Y*0 NEAR THE LAMBDA OR SIGMA MASS WAS MADE BY TAN 69. NONE WAS FOUND.

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REFERENCES — Y*0(1330)

Y-CHANG 64 DUBNA CONF I 615 YUNG-CHANG, IN, KLADNITSKAYA, + (DUBNA)
BUBELEV 67 PL 24B 246 +CHADRAA, CHUVILO, + (JINR,BUCHAREST,CERN)
DAHL 67 PR 163 1377 DAHL, HARDY, HESS, KIRZ, MILLER (LRL)
BOZOKI 68 PL 28B 360 +FENYVES, GEMESY, + (BUDAPEST,DUBNA)
TAN 69 PRL 23 101 T H TAN (SLAC)

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Λ(1405) S_{01}

37 Y*0(1405, JP=1/2-) I=0

THIS RESONANCE CAN BE IDENTIFIED WITH THE VIRTUAL BOUND STATE IN THE KBAR-N SYSTEM FOUND IN THE ANALYSIS OF LOW ENERGY K-P INTERACTION. WE LIST SUCH EXPERIMENTS SEPARATELY BELOW. WE USE ONLY PRODUCTION EXPERIMENTS FOR AVERAGING OF MASSES AND WIDTHS -

37 Y*0(1405) MASS (MEV)

M		(1405.0)		ALSTON	61 HBC	K-P 1.15 BEV/C	
M		(1410.0)		ALEXANDER	62 HBC	PI-P 2.1 BEV/C	
M		(1405.0)		ALSTON	62 HBC	K-P 1.2-.5 BEV/C	
M		1400.0	24.0	MUSGRAVE	65 HBC	PBAR P 3-4 BEV/C	7/66
M		(1382.0)	(8.0)	ENGLER	65 HDBC	PI-P, PI+D 1.68	7/66
M	67	1400.0	5.0	BIRMINGHA	66 HBC	3.5 K- P	9/67
M	120	1405.0	5.0	GALTIERI	68 DBC	K-D 2.1-2.7BEV/C	6/68
M		. . . . .	. . . . .				
M	AVG	1402.4	3.5	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

37 Y*0(1405) WIDTH (MEV)

W		(20.0)		ALSTON	61 HBC		7/66
W		35.0	5.0	ALEXANDER	62 HBC		
W		(50.0)		ALSTON	62 HBC		
W		60.0	20.0	MUSGRAVE	65 HBC		7/66
W		(89.0)	(20.0)	ENGLER	65 HDBC		7/66
W	67	50.0	10.0	BIRMINGHA	66 HBC	3.5 K- P	9/67
W	120	35.0	8.0	GALTIERI	68 DBC	K-D 2.1-2.7BEV/C	6/68
W		. . . . .	. . . . .				
W	AVG	38.1	3.9	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)			

37 Y*0(1405) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*0(1405) INTO SIGMA PI	1197+ 139

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REFERENCES — Y*0(1405)

ALSTON 61 PRL 6 698 +ALVAREZ,EBERHARD,GOOD,GRAZIANO, + (LRL) I
ALEXANDE 62 PRL 8 447 ALEXANDER,KALBFLEISCH,MILLER,SMITH (LRL) I
ALSTON 62 CERN CONF 311 +ALVAREZ,FERRO-LUZZI,ROSENFELD, + (LRL) I
MUSGRAVE 65 NC 35 735 +PETMEZAS,+ (BIRMGHM,CERN,EP,IMPCOL,SACLAY)
ENGLER 65 PRL 15 224 +FISK,KRAEMER,MELTZER,WESTGARD,+ (CRNG,BNL) IJ

BIRMINGH 66 PR 152 1148 BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
GALTIERI 68 PRL 21 573 BARBARO-GALTIERI,CHADWICK + (LRL,SLAC)

PAPERS NOT REFERRED TO IN DATA CARDS.

ABRAMS 65 PR 139 B454 G S ABRAMS, B SECHI-ZORN (MD)IJP
KADYK 66 PRL 17 599 +OREN, G+S GOLDHABER, TRILLING (LRL)IJP
DONALD 66 PL 22 711 + EDWARDS, LYS, NISAR, MOORE (LIVERPOOL)
-- ABRAMS 65, KADYK 66, AND DONALD 66 SUPPORT THOSE EFFECTIVE-RANGE-FIT SOLUTIONS GIVING AN I=0 S1/2 RESONANCE.

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37 Λ(1405) EXTRAPOLATION BELOW THRESHOLD

SEE NOTE IN Y*0(1405) PRODUCTION EXPERIMENTS -THE DIFFICULTIES IN EXTRAPOLATING FROM THE PHYSICAL REGION TO THE RESONANCE LOCATION ARE DISCUSSED BY DALITZ 67.

37 Y*0(1405) MASS (MEV)

M		(1410.7)	(1.0)	KIM	65 HBC	O-EFF-RANGE FIT	7/66
M	N	(1409.6)	(1.7)	SAKITT	65 HBC	O-EFF-RANGE FIT	7/66
M	N	DATA OF SAKITT ARE USED IN FIT BY KITTEL.					
M		(1407.5)	(1.2)	KITTEL	66 HBC	O-EFF-RANGE FIT	7/66
M		(1403.0)	(3.0)	KIM	67 HBC	K MATRIX FIT(KP)	8/67
M		(1416.0)	(4.0)	MARTIN	69 HBC	CONST. K MATRIX	10/69*

37 Y*0(1405) WIDTH (MEV)

W		(37.0)	(3.2)	KIM	65 HBC		7/66
W	N	(28.2)	(4.1)	SAKITT	65 HBC		7/66
W		(34.1)	(4.1)	KITTEL	66 HBC		7/66
W		(50.0)	(5.0)	KIM	67 HBC	K MATRIX FIT(KP)	8/67
W		(29.0)	(6.0)	MARTIN	69 HBC	CONST. K MATRIX	10/69*

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Data in parentheses have not been included in our averages.


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                    REFERENCES -- Y*0(1405) FROM EXTRAPOLATIONS

KIM      65 PRL 14 29        J K KIM                              (COLUMBIA)IJP
SAKITT   65 PR 139 B719      +DAY,GLASSER,SEEMAN,FRIEDMAN, +      (MD,LRL)IJP
KITTEL   66 PL 21 349        W KITTEL, G OTTER, I WACEK          (VIENNA)IJP
DALITZ   67 PR 153 1617      DALITZ, WONG, RAJASEKARAN    (OXFORD,BOMBAY)
KIM      67 PRL 19 1074      J KIM                                   (YALE)JP
MARTIN   69 PR 183 1352      B R MARTIN, M SAKITT                 (UCL+BNL)
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               END -EXTRAPOLATION BELOW THRESHOLD-

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Λ(1520) D'_{03}

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38  Y*0(1520, JP=3/2-) I=0

PRODUCTION AND FORMATION EXPERIMENTS AGREE QUITE WELL
WITH EACH OTHER ,THEREFORE THEY HAVE NOT BEEN SEPARATED
FOR THIS PARTICLE

---------------     38  Y*0(1520) MASS (MEV)     -------------------------

M          1519.4      2.0         WATSON    63 HBC    K-P ALL CHANNELS
M      . 145 1517.2    3.0         GALTIERI  63 DBC    K-D 1.51 BEV/C
M        29 1520.0     4.0         ALMEIDA   64 HBC    K-P 1.45 BEV/C
M         (1511.0)   (15.0)        MUSGRAVE  65 HBC    PBAR P 3-4 BEV/C  7/66
M        30(1510.0)   (2.0)        BIRMINGHA 66 HBC     3.5 K- P         9/67
M    B     1517.2      1.2         BURKHARDT 69 HBC    K-P .8-1.2 GEV/C 10/69*
M    B          QUOTED ERROR INCREASED TO ACCOUNT FOR DISAGREEMENT BETWEEN
M    B          TWO MEASUREMENTS DONE BY SAME AUTHORS (K-P AND SIGMA PI)
M          . . . . . . . . . .
M   AVG    1517.85     0.95    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

--------------    38  Y*0(1520) WIDTH (MEV)    ---------------------------

W           16.4       2.0         WATSON    63 HBC
W          (19.0)    (19.0)        MUSGRAVE  65 HBC                      7/66
W      30  (50.0)    (10.0)        BIRMINGHA 66 HBC     3.5 K- P         9/67
W          (18.0)       OR LESS    DAHL      67 HBC                      9/66
W           14.7       1.8         BURKHARDT 69 HBC    K-P .8-1.2 GEV/C 10/69*
W          . . . . . . . . . .
W   AVG     15.5       1.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------    38  Y*0(1520) PARTIAL DECAY MODES   ------------------

                                                        DECAY MASSES
P1          Y*0(1520) INTO KBAR N                        497+ 939
P2          Y*0(1520) INTO SIGMA PI                     1197+ 139
P3          Y*0(1520) INTO LAMBDA PI PI                 1115+ 139+ 139
P4          Y*0(1520) INTO LAMBDA GAMMA                 1115+   0
P5          Y*0(1520) INTO SIGMA0 GAMMA                 1192+   0
P6          Y*0(1520) INTO SIGMA PI PI                  1197+ 139+ 139
P7          Y*0(1520) INTO (Y*1(1385)+PI)               1385+ 139

----------------    38  Y*0(1520) PARTIAL WIDTHS (MEV)    ----------------

W1          Y*0(1520) INTO KBAR N                       (P1)
W1  0        (4.8)     (0.5)        WATSON     63 HBC
W1  0            FOR NEW RESULTS SEE GALTIERI 69 BELOW

W2          Y*0(1520) INTO SIGMA PI                     (P2)
W2  0        (9.0)     (1.0)        WATSON     63 HBC
W2  0            FOR NEW RESULTS SEE GALTIERI 69 BELOW

----------------    38  Y*0(1520) BRANCHING RATIOS    --------------------

R1      Y*0(1520) INTO (SIGMA PI)/(KBAR N)               (P2)/(P1)
R1           1.72      .78         MUSGRAVE  65 HBC                      8/67
R1           0.73      0.11        DAUBER    67 HBC    K-P AT 2.GEV/C    8/67
R1           0.96      0.20        DAHL      67 HBC    PI-P 1.6-4 GEV/C  9/66
R1           1.06      .14         SCHEUER   68 DBC  0 K-N 3 GEV/C      10/69*
R1           0.82      0.08        BURKHARDT 69 HBC    K-P .8-1.2 GEV/C 10/69*
R1          . . . . . . . . . .
R1  AVG      0.851     0.064   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R1  FIT      0.891     0.037    VALUE FROM CONSTRAINED FIT

R2      Y*0(1520) INTO (LAMBDA PI PI)/(KBAR N)           (P3)/(P1)
R2           0.21      0.18        DAUBER    67 HBC    K-P AT 2.GEV/C    8/67
R2           0.17      0.05        DAHL      67 HBC    PI-P 1.6-4 GEV/C  9/66
R2            .19       .04        SCHEUER   68 DBC  0 K-N 3 GEV/C      10/69*
R2           0.22      0.03        BURKHARDT 69 HBC    K-P .8-1.2 GEV/C 10/69*
R2          . . . . . . . . . .
R2  AVG      0.202     0.021   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R2  FIT      0.210     0.017    VALUE FROM CONSTRAINED FIT

R3     Y*0(1520) INTO (SIGMA PI)/(LAMBDA PI PI)          (P2)/(P3)
R3           4.5       1.0         ARMENTERO 65 HBC                      7/66
R3           3.3       1.1         BIRMINGHA 66 HBC      3.5 K- P        9/67
R3           3.9       1.0         UHLIG     67 HBC    K-P .9-1.0 BEV/C  9/66
R3          . . . . . . . . . .
R3  AVG      3.94      0.59    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R3  FIT      4.24      0.35     VALUE FROM CONSTRAINED FIT

R4      Y*0(1520) INTO (LAMBDA GAMMA)/TOTAL  (PERCENT)   (P4)/TOTAL
R4   238     0.80      0.14        MAST      68 HBC  0 USING ELAST=.45  11/68
R4          . . . . . . . . . .
R4  FIT      0.80      0.14     VALUE FROM CONSTRAINED FIT

R5      Y*0(1520) INTO (SIGMA0 GAMMA)/TOTAL  (PERCENT)   (P5)/TOTAL
R5   S       2.0       .35         MAST      68 HBC     SEE NOTE S      10/69*
R5   S    RATIOS CALCULATED FROM R4,ASSUMING SU(3). NEEDED TO CONSTRAIN
R5   S    ALL THE Y*0(1520) BRANCHING RATIOS TO BE UNITY.
R5          . . . . . . . . . .
R5  FIT      2.00      0.35     VALUE FROM CONSTRAINED FIT

R6          Y*0(1520) INTO (KBAR N)/TOTAL                (P1)/TOTAL
R6           .447      .018        GALTIERI  69 HBC    K-P .28-.45GEV/C 10/69*
R6          . . . . . . . . . .
R6  FIT      0.4579    0.0097   VALUE FROM CONSTRAINED FIT

R7          Y*0(1520) INTO (SIGMA PI)/TOTAL      69 HBC  (P2)/TOTAL
R7           .418      .017        GALTIERI  69 HBC  0 K-P .28-.45GEV/C 10/69*
R7          . . . . . . . . . .
R7  FIT      0.4078    0.0099   VALUE FROM CONSTRAINED FIT

R8          Y*0(1520) INTO (SIGMA PI PI)/TOTAL           (P6)/TOTAL
R8           .010      .0015       GALTIERI  69 HBC  0 K-P .28-.45GEV/C 10/69*
R8          . . . . . . . . . .
R8  FIT      0.0100    0.0015   VALUE FROM CONSTRAINED FIT

R9          Y*0(1520) INTO (Y*1(1385)+PI)/(LAM PI PI)    (P7)/(P3)
R9           .35       .09         ARMENTER  69 HBC  +- K-P .77 TO 1.23  10/69*
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients = $\langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.458+-.010					
P 2	-.704	.408+-.010				
P 3	-.289	-.361	.096+-.007			
P 4	-.063	-.055	-.034	.008+-.001		
P 5	-.158	-.137	-.085	-.006	.020+-.003	
P 6	-.067	-.059	-.036	-.003	-.006	.010+-.001

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                         REFERENCES -- Y*0(1520)

WATSON   63 PR 131 2248      M B WATSON, M FERRO-LUZZI, R D TRIPP  (LRL)IJP
GALTIERI 63 PL 6 296         A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)
ALMEIDA  64 PL 9 204         S P ALMEIDA, G R LYNCH                (CERN)
MUSGRAVE 65 NC 35 735        +PETMEZAS,+ (BIRMGHM,CERN,EP,IMPCOL,SACLAY)
ARMENTER 65 PL 19 338        ARMENTEROS,F-LUZZI, +  (CERN,HEIDEL,SACLAY)

BIRMINGH 66 PR  152  1148    BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
DAHL     67 PR 163 1377      DAHL,HARDY,HESS,KIRZ,MILLER            (LRL)
DAUBER   67 PL 24B 525       +MALAMUD,SCHLEIN,SLATER,STORK         (UCLA)
UHLIG    67 PR 155 1448      +CHARLTON,CONDON,GLASSER,YODH,+  (MD,USNRL)
MAST     68 PRL 21 1715      MAST,ALSTON,BANGERTER,GALTIERI+        (LRL)
SCHEUER  68 NP B8 503        SABRE COLLAB.    (SACL+AMST+BGNA+REHO+EPOL)

ARMENTER 69 LUND PAPER       ARMENTEROS,FERRO LUZZI +         (CERN+HEID)
BURKHARD 69  LUND PAPER      +FILTHUTH,KLUGE +      (HEID+EFIN+CERN+SACL)
GALTIERI 69  LUND PAPER 91   BARBARO-GALTIERI,BANGERTER,MAST,TRIPP (LRL)
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Λ(1670) S'_{01}

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40  Y*0(1670, JP=1/2-) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

 THIS RESONANCE IS WELL ESTABLISHED.
 (SEE THE NOTE FOR THE Y*0(1330)).

----------------    40  Y*0(1670) MASS (MEV)    --------------------------

M   M     (1666.0)OR(1675.0)         BERLEY    65 HBC  0  K-P TO LAM ETA    7/66
M   M    THE FIRST VALUE ASSUMES THE BRANCHING RATIO INTO LAMBDA ETA IS
M       SMALL, THE SECOND THAT IT IS LARGE.  BECAUSE THE RESONANCE IS NEAR
M       THE LAMBDA ETA THRESHOLD, THE BRANCHING RATIO AFFECTS THE MOMENTUM
M       DEPENDENCE OF THE TOTAL WIDTH, AND THUS ALSO THE RESONANCE PARA-
M       METERS OBTAINED BY FITTING TO THE DATA.
M         (1663.0)     (3.0)         ARMENT-1  68 HBC  0  ELASTIC, CH EXCH 11/68
M         (1678.0)     (2.0)         ARMENT-2  68 HBC  0  K-P TO SIGMA PI  11/68
M   N     (1662.0)     (3.0)         ARMENT-4  69 HBC  0  ELAST,CH.EXC.ED   9/69*
M   N     (1680.0)     (1.0)         ARMENT-4  69 HBC  0  K-P TO SIG PI.ED  9/69*
M   A     (1674.0)     (5.0)         ARMENT-3  69 HBC  0  MULTICHANNEL      9/69*
M   A           THE MULTICHANNEL ANALYSIS INCLUDES ELASTIC AND SIGMA PI .  10/69*
M   N    THE APPARENT DISCREPANCY BETWEEN THESE RESULTS IS PROBABLY NOT
M       SERIOUS.  THE ERRORS GIVEN ARE JUST STATISTICAL.  THE SYSTEMATIC
M       ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETERIZATION FORCED ON
M       THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.

----------------    40  Y*0(1670) WIDTH (MEV)    -------------------------

W   M      (22.0)OR(15.0)            BERLEY    65 HBC  0  SEE NOTE M ABOVE  7/66
W          (26.0)     (8.0)          ARMENT-1  68 HBC  0  SEE NOTE N ABOVE 11/68
W          (26.0)     (5.0)          ARMENT-2  68 HBC  0                   11/68
W   A      (23.0)     (3.0)          ARMENT-3  69 HBC  0                    9/69*
W   N      (38.0)    (15.0)          ARMENT-4  69 HBC  0  ELAST,CH EXC.ED   9/69*
W   N      (33.0)     (5.0)          ARMENT-4  69 HBC  0  K-P TO SIG PI.ED  9/69*
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------    40  Y*0(1670) PARTIAL DECAY MODES    -----------------

                                                          DECAY MASSES
P1          Y*0(1670) INTO KBAR N                          497+ 939
P2          Y*0(1670) INTO LAMBDA ETA                     1115+ 548
P3          Y*0(1670) INTO SIGMA PI                       1189+ 139

----------------    40  Y*0(1670) BRANCHING RATIOS    --------------------

R1      Y*0(1670) INTO (KBAR N)/TOTAL                      (P1)/TOTAL
R1   P        (0.14)     (0.04)      ARMENT-1  68 HBC  0  OLD DATA         11/68
R1   P         0.14       0.04       ARMENT-4  69 HBC  0  NEW DATA          9/69*
R1   P   THIS IS THE DIAMETER OF THE CIRCLE IN THE ARGAND PLOT.  IT IS
R1       SUPERIMPOSED ON A LARGE BACKGROUND.
R1            (0.17)                 ARMENT-3  69 HBC  0                    9/69*

R2      Y*0(1670).INTO (KBAR N)*(LAMBDA ETA)/TOTAL**2     (P1*P2)/TOTAL**2
R2   M        (0.039)OR 0.053        BERLEY    65 HBC  0  SEE NOTE M ABOVE  7/66
R2            (0.066)                ARMENT-3  69 HBC  0                    9/69*

R3      Y*0(1670) INTO (KBAR N)*(SIGMA PI)/TOTAL**2       (P1*P3)/TOTAL**2
R3          PERHAPS SEEN             BIRMING-  66 HBC  0  K-P 3.5 GEV/C    11/67
R3           (0.062)  (0.030)        ARMENT-2  68 HBC  0  OLD DATA
R3           (0.075)                 ARMENT-3  69 HBC  0                    9/69*
R3            0.090    0.018         ARMENT-4  69 HBC  0  NEW DATA          9/69*

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                      REFERENCES -- Y*0(1670)

BERLEY   65 PRL 15 641        +CONNOLLY, HART, RAUM, STONEHILL, +   (BNL)IJP
BIRMING- 66 PR 152 1148       (BIRMINGHAM,GLASGOW,IMPCOL,OXFORD,RUTHERFD)
ARMENT-1 68 NP B8 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP B8 223         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP

ARMENT-3 69 LUND PAPER 229    ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
      --  ARMENTEROS 3 VALUES  ARE QUOTED IN LEVI SETTI 69.
ARMENT-4 69 NP(SUB)CERN 69-13 ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
LEVISETT 69 LUND CONF         R LEVI SETTI  (RAPPORTEUR)        (CHICAGO) .
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

Λ(1680) P'_{01}

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88  Y*0(1680, JP=1/2+) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THERE ARE TWO PARTIAL WAVE ANALYSES OF K- P TO SIGMA
PI THAT SUGGEST SUCH A RESONANCE, BUT FURTHER CON-
FIRMATION IS REQUIRED. POSSIBLY THIS RESONANCE CAN
EVENTUALLY BE ASSOCIATED WITH THE Y*0(1800), WHICH IS SUGGESTED BY
PARTIAL WAVE ANALYSES OF THE KBAR N CHANNEL AND ALSO HAS JP=1/2+.

----------------  88  Y*0(1680) MASS (MEV)  --------------------------

M   A    (1670.0)                  ARMENTERO 69 HBC  0  K-P TO SIGPI.EI    9/69*
M   A     THIS STATE FOUND ONLY IN THE ENERGY INDIPENDENT ANALYSIS
M        (1700.0)                  GALTIERI  69 HBC  0  K-P TO SIGPI.ED    9/69*

----------------  88  Y*0(1680) WIDTH (MEV)  -------------------------

W          (40.0)                  ARMENTERO 69 HBC  0                     9/69*
W          (80.0)                  GALTIERI  69 HBC  0                     9/69*

----------------  88  Y*0(1680) PARTIAL DECAY MODES  -----------------

                                                        DECAY MASSES
P1       Y*0(1680) INTO KBAR N                        497+ 939
P2       Y*0(1680) INTO SIGMA PI                     1189+ 139

----------------  88  Y*0(1680) BRANCHING RATIOS  --------------------

R1    Y*0(1680) INTO (KBAR N)*(SIGMA PI)/TOTAL**2      (P1*P3)/TOTAL**2
R1         (0.040)                 ARMENTERO 69 HBC  0                     9/69*
R1         (0.014)                 GALTIERI  69 HBC  0                     9/69*

R2       Y*0(1680) INTO (KBAR N)/TOTAL                 (P1)/TCTAL
R2     LESS THAN .1                ARMENTE1  69 HBC     K-P +CH EXC. EI   10/69*

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REFERENCES -- Y*0(1680)


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ARMENTE1 69  LUND PAPER 225   ARMENTEROS,BAILLON, +      (CERN+HEID+SACL)IJP
ARMENTER 69 LUND PAPER 224    ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
GALTIERI 69 LUND PAPER 90     A BARBARO-GALTIERI                     (LRL)IJP
    -- ARMENTEROS 69 AND GALTIERI 69 VALUES ARE QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CONF         R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)
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Λ(1690) D''_{03}

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55  Y*0(1690, JP=3/2-) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THIS RESONANCE IS WELL ESTABLISHED.

----------------  55  Y*0(1690) MASS (MEV)  --------------------------

M   S    (1695.0)   (4.0)          BUGG      68 CNTR 0  K-P, D TOTAL       7/68
M        (1696.0)   (3.0)          ARMENT-1  68 HBC  0  ELASTIC, CH EXCH  11/68
M        (1681.0)   (2.0)          ARMENT-3  68 HBC  0  K-P TO SIGMA PI   11/68
M   S    (1681.)    (8.)           BARTLEY   68 DBC   0 K-P AND K-D DATA  11/68
M   S          QUOTED ERROR ONLY STATISTICAL -VALUES NOT AVERAGED-
M   M    (1697.0)   (2.0)          CCNFORTO  68 HBC  0  ELASTIC, CH EXCH  11/68
M   M     THE Y*0(1690) IS AT THE EDGE OF THE ENERGY REGION ANALYZED BY
M       CONFORTO.  THE SAME DATA AS WELL AS OTHERS EXTENDING TO LOWER
M       ENERGIES ARE INCLUDED IN ARMENTEROS 1.

M   S    (1701.0)   (4.0)          BERTANZA  69 HBC  0  ELASTIC, CH EXCH   9/69*
M   A    (1691.0)   (2.0)          ARMENT-4  69 HBC  0  ELAS,CH EXC.ED     9/69*
M   A    (1688.0)   (2.0)          ARMENT-4  69 HBC  0  K-P TO SIG PI.ED   9/69*
M   A     ANALYSIS INCLUDES OLD AND NEW DATA OF CHS COLLAB.  .43-.8 GEV/C  10/69*
M   N     THE APPARENT DISCREPANCY BETWEEN THE SIGMA PI AND OTHER RESULTS IS
M   N   PROBABLY NOT SERIOUS.  THE EPRORS GIVEN ARE JUST STATISTICAL.  THE
M   N   SYSTEMATIC ERRORS THAT RESULT FROM THE RESTRICTIVE PARAMETE-+S+0+0-
M   N   OF THE PARTIAL-WAVE AMPLITUDES ARE NOT INCLUDED, AND CAN BE LARGE.

----------------  55  Y*0(1690) WIDTH (MEV)  -------------------------

W          (35.0)   (7.0)          ARMENT-1  68 HBC  0  OLD DATA          11/68
W          (85.0)   (7.0)          ARMENT-3  68 HBC  0  OLD DATA          11/68
W   S      (40.0)   (7.0)          BUGG      68 CNTR 0                     7/68
W   S      (48.)   (15.)           BARTLEY   68 DBC   0 K-P AND K-D DATA  11/68
W   M      (27.0)   (5.0)          CONFORTO  68 HBC  0  SEE NCTE M ABOVE  11/68
W   A      (31.0)   (7.0)          ARMENT-4  69 HBC  0  ELAS,CH EXC.ED     9/69*
W   A      (72.0)   (6.0)          ARMENT-4  69 HBC  0  K-P TO SIG PI ED   9/69*
W   S      (28.0)   (8.0)          BERTANZA  69 HBC  0                     9/69*
            SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------  55  Y*0(1690) PARTIAL DECAY MODES  -----------------

                                                        DECAY MASSES
P1       Y*0(1690) INTO KBAR N                        497+ 939
P2       Y*0(1690) INTC SIGMA PI                     1189+ 139
P3       Y*0(1690) INTO LAMBDA PI PI                 1115+ 139+ 139
P4       Y*0(1690) INTO SIGMA PI PI                  1189+ 139+ 139

----------------  55  Y*0(1690) BRANCHING RATIOS  --------------------

   THE SUM OF ALL THE QUOTED BRANCHING RATIOS IS MORE THAN 1.0.  THE
 TWO-BODY RATIOS ARE FROM PARTIAL WAVE ANALYSES, AND THUS PROBABLY ARE
 MCRE RELIABLE THAN THE THREE-BODY RATIOS, WHICH ARE DETERMINED FROM
 BUMPS IN CROSS SECTIONS.  OF THE LATTER, THE SIGMA PI PI BUMP LOOKS
 MORE SIGNIFICANT (THE ERROR GIVEN FOR THE LAMBDA PI PI RATIO LOOKS UN-
 REASONABLY SMALL).  HARDLY ANY OF THE SIGMA PI PI DECAY CAN BE VIA
 Y*1(1385), FOR THEN NINE TIMES AS MUCH LAMBDA PI PI DECAY WOULD BE
 REQUIRED.

R1    Y*0(1690) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1         (0.23)                  BUGG      68 CNTR 0  ASSUMING J=3/2     7/68
R1         (0.18)   (0.03)         ARMENT-1  68 HBC  0                    11/68
R1  M      (0.22)   (0.03)         CONFORTO  68 HBC  0  SEE NOTE M ABOVE  11/68
R1          0.28     0.04          BERTANZA  69 HBC  0                     9/69*
R1          0.18     0.02          ARMENT-4  69 HBC  0  NEW DATA           9/69*
R1         . . . . . . . . . .
R1  AVG     0.200    0.040    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)

R2    Y*0(1690) INTO (KBAR N)*(SIGMA PI)/TOTAL**2      (P1*P2)/TOTAL**2
R2         (0.109)  (0.013)        ARMENT-3  68 HBC  0  OLD DATA          11/68
R2          0.130    0.014         ARMENT-4  69 HBC  0  NEW DATA           9/69*

R3    Y*0(1690) INTO (KBAR N)*(LAMBDA PI PI)/TOTAL**2  (P1*P3)/TOTAL**2
R3         (0.06).  (0.01)         BARTLEY   68 HDBC 0  K-N TC LAM PI PI  11/68

R4    Y*0(1690) INTO (KBAR N)*(SIGMA PI PI)/TOTAL**2   (P1*P4)/TOTAL**2
R4         (0.045)                 ARMENT-2  68 HDBC 0  K-N TO SIG PI PI  11/68

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REFERENCES -- Y*0(1690)


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DAVIES   67 PRL 18 62          +DOWELL, +              (BRMNGHM,CVNDSH,RTHFRD) I
    --  REPLACED BY BUGG 68.
ARMENT-1 68 NP 88 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP 88 216          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
ARMENT-3 68 NP 88 223          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BARTLEY  68 PRL 21 1111        +CHU,DOWD,GREENE,+ (TUFTS,FLOR ST,BRANDEIS) I
BUGG     68 PR 168 1466        +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) I
CONFORTO 68 NP 88 265          +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
ARMENT-4 69 NP (SUB)CERN 69-13ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BERTANZA 69 PR 177 2036        +BIGI,CARRARA,CASALI, +      (PISA,BNL,YALE)IJP
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Λ(1800) P''_{01}

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77  Y*0(1800, JP=1/2+) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE EVIDENCE FOR THIS STATE IS WEAK AND CONFUSED.  IT
WAS FIRST SUGGESTED IN A PARTIAL WAVE ANALYSIS OF KBAR
N DATA BY THE BEHAVIOR OF THE P01 AMPLITUDE WHEN IT
WAS PARAMETERIZED AS A TWO-STRAIGHT-LINE BACKGROUND.  WHEN IT WAS RE-
PARAMETERIZED AS A RESONANCE SUPERIMPOSED ON A ONE-STRAIGHT-LINE BACK-
GROUND, A BROAD RESCNANCE RESULTED (ARMENTEROS 68).  A REANALYSIS OF
ESSENTIALLY THE SAME DATA, BUT THIS TIME WITH THE P01 AMPLITUDE UNCON-
STRAINED, SUGGESTED A MUCH NARROWER RESONANCE AT HIGHER ENERGY (ARMEN-
TEROS 69).  IT IS QUITE POSSIBLE THAT NEITHER RESONANCE EXISTS.

----------------  77  Y*0(1800) MASS (MEV)  --------------------------

M        (1745.0)                  ARMENTERO 68 HBC  0  ELASTIC, CH EXCH 11/68
M         ABOUT 1800.0             ARMENTERO 69 HBC  0  ELAS,CH EXC. E.I  9/69*

----------------  77  Y*0(1800) WIDTH (MEV)  -------------------------

W        (147.0)                   ARMENTERO 68 HBC  0
W         ABOUT 20.0               ARMENTERO 69 HBC  0  K-P .44 - 1.23    9/69*

----------------  77  Y*0(1800) PARTIAL DECAY MODES  -----------------

                                                        DECAY MASSES
P1       Y*0(1800) INTO KBAR N                        497+ 939

----------------  77  Y*0(1800) BRANCHING RATIOS  --------------------

R1    Y*0(1800) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1         (0.4)                   ARMENTERO 68 HBC                      11/68
R1        ABOUT 0.2                ARMENTERO 69 HBC                       9/69*

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REFERENCES -- Y*0(1800)


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ARMENTER 68 NP 88 195         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENTER 69 LUND PAPER 225    ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
    -- ARMENTEROS 69 IS QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CONF         R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)
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Λ(1815) F_{05}

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39  Y*0(1815, JP=5/2+) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THIS RESONANCE IS AS WELL ESTABLISHED AS ANY Y*, AL-
THOUGH SOME OF THE LESSER BRANCHING RATIOS NEED TO BE
BETTER DETERMINED.  WE OMIT A FEW EARLY RESULTS (SEE
AN EARLIER EDITION FOR THEM), THOUGH THE REFERENCES ARE RETAINED.  THE
QUOTED ERRORS ARE JUST STATISTICAL, AND DCNT INCLUDE SYSTEMATIC EF-
FECTS.  HOWEVER IN THIS CASE THE LATTER SHOULD BE SMALL, AND THE VAR-
IOUS DETERMINATIONS CF MASS, WIDTH, AND ELASTICITY ARE IN GOOD AGREE-
MENT.  A REASONABLE GUESS OF THESE PARAMETERS AND THEIR ERRORS IS
1816+-3 MEV, 72+-5 MEV, AND 0.65+-0.05.

----------------  39  Y*0(1815) MASS (MEV)  --------------------------

M          1813.0     2.0          ARMENT-1  67 HBC  0  K-P TO SIGMA PI    8/67
M          1816.0     4.0          BELL      67 HDBC 0  K-N TO SIGMA PI   11/67
M   N      1817.0     2.0          ARMENT-3  68 HBC  0  ELASTIC, CH EXCH  11/68
M          1819.0     4.0          BUGG      68 CNTR 0  K-P, D TOTAL       6/68
M   N      1816.0     2.0          CONFORTO  68 HBC  0  ELASTIC, CH EXCH  11/68
M   N    THESE TWO ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS.
M         . . . . . . . . . .
M   AVG    1815.6     1.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  39  Y*0(1815) WIDTH (MEV)  -------------------------

W            87.0    15.0          ARMENT-1  67 HBC  0                     8/67
W            64.0    12.0          BELL      67 HDBC 0                    11/67
W   N        71.0     4.0          ARMENT-3  68 HBC  0  SEE NOTE N ABOVE  11/68
W            75.0     7.0          BUGG      68 CNTR 0                     6/68
W   N        72.0     7.0          CONFORTO  68 HBC  0  SEE NOTE N ABOVE  11/68
W         . . . . . . . . . .
W   AVG      72.1     3.0     AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.0)
            SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------  39  Y*0(1815) PARTIAL DECAY MODES  -----------------

                                                        DECAY MASSES
P1       Y*0(1815) INTO KBAR N                        497+ 939
P2       Y*0(1815) INTO SIGMA PI                     1189+ 139
P3       Y*0(1815) INTO Y*1(1385) PI                 1385+ 139
P4       Y*0(1815) INTO LAMBDA PI PI                 1115+ 139+ 139
P5       Y*0(1815) INTO SIGMA PI PI                  1192+ 139+ 139

----------------  39  Y*0(1815) BRANCHING RATIOS  --------------------

R1    Y*0(1815) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1  N       0.62     0.02          ARMENT-3  68 HBC  0  SEE NOTE N ABOVE  11/68
R1         (0.72)                  BUGG      68 CNTR 0                     6/68
R1  N       0.65     0.01          CONFORTO  68 HBC  0  SEE NOTE N ABOVE  11/68
R1        . . . . . . . . . .
R1  AVG     0.644    0.012    AVERAGE (ERROR INCLUDES SCALE FACTOR CF 1.3)
R1  FIT     0.6437   0.0089   VALUE FROM CONSTRAINED FIT

R2    Y*0(1815) INTO (KBAR N)*(SIGMA PI)/TOTAL**2      (P1*P2)/TOTAL**2
R2          0.0729   0.0054        ARMENT-1  67 HBC  0                     8/67
R2          0.054    0.012         BELL      67 HDBC 0                    11/67
R2        . . . . . . . . . .
R2  AVG     0.0697   0.0071   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
R2  FIT     0.0697   0.0050   VALUE FROM CONSTRAINED FIT
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Data in parentheses have not been included in our averages.

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R3     Y*0(1815) INTO (KBAR N)*(Y*1(1385) PI)/TOTAL**2   (P1*P3)/TOTAL**2
R3            0.09      0.03            ARMENT-2  67 HBC  0  K-P TO LAM PI PI  9/69*
R3          . . . . . . . . . .
R3  FIT       0.108     0.022     VALUE FROM CONSTRAINED FIT

R4     Y*0(1815) INTO (Y*1(1385) PI)/TOTAL                    (P3)/TOTAL
R4            0.20      0.05            BIRGE     65 HBC  0  K-P TO LAM PI PI  7/66
R4          . . . . . . . . . .
R4  FIT       0.168     0.034     VALUE FROM CONSTRAINED FIT

R5     Y*0(1815) INTO (SIGMA PI PI)/TOTAL                     (P5)/TOTAL
R5   P     NO CLEAR SIGNAL              ARMENT-4  68 HDBC 0  K-N TO SIG PI PI 11/68
R5   P   THERE IS A SUGGESTION OF A BUMP, ENOUGH TO BE CONSISTENT WITH
R5     WHAT IS EXPECTED FROM SIGMA PI DECAY OF THE Y*1(1385) -- ABOUT 0.02.
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients $= \langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4
P 1	.644+-.009			
P 2	-.190	.108+-.008		
P 3	-.043	.008	.168+-.034	
P 4	-.169	-.183	-.953	.080+-.035

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REFERENCES -- Y*0(1815)


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BIRGE    65 ATHENS CONF  296   +ELY,KALMUS,KERNAN,LOUIE,SAHOURIA, +  (LRL)IJP
ARMENT-1 67 PL 24B 198         ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 67 ZEIT PHYS 202 486  ARMENTEROS, F LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL     67 PRL 19 936         R B BELL                               (LRL)IJP
ARMENT-3 68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-4 68 NP B8 216          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
BUGG     68 PR 168 1466        +GILMORE, KNIGHT,   +    (RHEL+BIRM+CAVE) I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +    (CHICAGO,HEIDEL)IJP
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PAPERS NOT REFERRED TO IN DATA CARDS.

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CHAMBERL 62 PR 125 1696        CHAMBERLAIN,CROWE,KEEFE,KERTH, +       (LRL) I
GALTIERI 63 PL 6 296           A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)IJ
SODICKSO 64 PR 133 B757        SODICKSON,MANNELLI,FRISCH,WAHLIG (MIT(BNL)) J
HOLLEY   65 UCRL-16274 THESIS  W R HOLLEY                             (LRL) J
BIRMINGH 66 PR  152  1148      BIRMINGHAM,GLASGOW,I.C., OXFORD,RUTHERFORD
GELFAND  66 PRL 17 1224        +HARMSEN,LEVI-SETTI,PREDAZZI+ (EFINS,ARGON)
ARMENTER 67 NP B3 592          ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)IJP
LASINSKI 68 PR 163 1792        LASINSKI, LEVI SETTI, PREDAZZI    (CHICAGO) JP
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Λ(1830) D05

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56  Y*0(1830, JP=5/2-) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE BEST EVIDENCE FOR THIS RESONANCE COMES FROM THE
SIGMA PI CHANNEL.  IT APPEARS TO BE WELL ESTABLISHED.

----------------  56  Y*0(1830) MASS (MEV)  -------------------------

M   A     (1827.0)    (3.0)          ARMENTERO 67 HBC  0  K-P TC SIGMA PI   8/67
M   A     (1837.0)   (11.0)          BELL      67 HBC  0  K-P TO SIGMA PI  11/67
M   N     (1807.0)   (10.0)          ARMENTERO 68 HBC  0  ELASTIC, CH EXCH 11/68
M   N     (1840.0)    (5.0)          CONFORTO  68 HBC  0  ELASTIC, CH EXCH 11/68
M   N   THESE ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS.
M   C     (1841.0)                   CONFORTO  69 HBC  0  ELASTIC, CH EXCH  9/69*
M   C           CONFORTO 69 IS A NEW FIT,USING IMPROVED  KBAR N DATA
M   A     NOT AVERAGED,AS FOR CARDS WITH NOTE N, BECAUSE SYSTEMATIC ERRORS,
M   A     DUE TO THE PARTICULAR PARAMETERIZATION USED, CAN BE LARGE

----------------  56  Y*0(1830) WIDTH (MEV)  -------------------------

W   A       (75.0)    (9.0)          ARMENTERO 67 HBC  0                    8/67
W   A       (74.0)   (18.0)          BELL      67 HBC  0                    8/67
W   N      (123.0)   (32.0)          ARMENTERO 68 HBC  0  SEE NOTE N ABOVE 11/68
W   N       (66.0)   (25.0)          CONFORTC  68 HBC  0  SEE NOTE N ABOVE 11/68
W   C      (145.0)                   CONFORTO  69 HBC  0  SEE NOTE N ABOVE  9/69*
          SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------  56  Y*0(1830) PARTIAL DECAY MODES  ----------------

                                                          DECAY MASSES
P1         Y*0(1830) INTO KBAR N                         497+ 939
P2         Y*0(1830) INTO SIGMA PI                      1189+ 139

----------------  56  Y*0(1830) BRANCHING RATIOS  -------------------

R1     Y*0(1830) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1   N        0.09      0.01         ARMENTERO 68 HBC  0  SEE NOTE N ABOVE 11/68
R1   N        0.10      0.01         CONFORTO  68 HBC  0  SEE NOTE N ABOVE 11/68
R1   A       (0.08)                  CONFORTO  69 HBC  0  SEE NOTE N ABOVE  9/69*
R1          . . . . . . . . . .
R1  AVG       0.0950    0.0071  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

R2     Y*0(1830) INTO (KBAR N)*(SIGMA PI)/TOTAL**2      (P1*P2)/TOTAL**2
R2            0.0225    0.0060       ARMENTERO 67 HBC  0                    8/67
R2            0.0374    0.0033       BELL      67 HBC  0                   11/67
R2          . . . . . . . . . .
R2  AVG       0.0339    0.0063  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)

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REFERENCES -- Y*0(1830)


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ARMENTER 67 PL 24B 198         ARMENTEROS, F-LUZZI, + (CERN,HEIDEL,SACLAY)IJP
BELL     67 PRL 19 936         R B BELL                               (LRL)IJP
ARMENTER 68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
CONFORTO 69 LUND CONF PAPER    + HARMSEN, LASINSKI, +     (CHICAGO,HEIDEL)IJP
     --  CONFORTO 69 NUMBERS ARE QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CONF          R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)
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Λ(1860)

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60  Y*0(1860, JP=   +) I=0

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE STATUS OF THIS RESONANCE -- OR THESE RESONANCES --
IS CONFUSED.  AN F07 RESONANCE WAS FIRST SUGGESTED IN
THE PHASE-SHIFT ANALYSIS OF KBAR N DATA BY ARMENTEROS
67.  IN ADDITION, THE ISOSPIN-0 TOTAL CROSS SECTION HAS A SHOULDER ON
THE HIGH SIDE OF THE Y*0(1815) THAT IS COMPATIBLE WITH SUCH A STATE
(BUGG 68).  THE ARMENTEROS 68 AND CONFORTO 68 ANALYSES OF IMPROVED
KBAR N DATA INCLUDED THE F07 STATE.  HOWEVER IN THE CONFORTO 69 ANALY-
SIS OF ESSENTIALLY THE SAME DATA, THE F07 RESONANCE IS OMITTED AND A
NEW P03 RESONANCE IS SUGGESTED.  THE QUANTITY (J+1/2)X FOR EITHER RE-
SONANCE ALONE IS ABOUT EQUAL TO THE VALUE GIVEN BY THE TOTAL-CROSS-
SECTION EXPERIMENT.  WE TENTATIVELY GROUP THE TWO EFFECTS TOGETHER.

   IF THERE IS INDEED A SPIN 7/2 Y* AT THIS MASS, IT LIES ABOVE ANY
PREVIOUSLY KNOWN Y* TRAJECTORY.

----------------  60  Y*0(1860) MASS (MEV)  -------------------------

M   A     (1870.0)    (5.0)          BUGG      68 CNTR 0  K-P TOTAL         7/68
M   A     DUE TO THE PARTICULAR PARAMETERIZATION USED, ERROR CAN BE LARGE
M   N  F07 1864.0      2.0           ARMENTERO 68 HBC  0  ELASTIC, CH EXCH 11/68
M   N  F07 1865.0      2.0           CONFORTO  68 HBC  0  ELASTIC, CH EXCH 11/68
M   N    THESE ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS.  THE
M   N  PARTIAL WAVE THOUGHT TO BE RESONATING IN EACH CASE IS INDICATED.
M   C  P03 1873.0     10.0           CONFORTO  69 HBC  0  ELASTIC, CH EXCH  9/69*
M   C     CONFORTO 69 IS A NEW FIT,USING IMPROVED KBAR N DATA

----------------  60  Y*0(1860) WIDTH (MEV)  -------------------------

W   A        (40.0)   (10.0)         BUGG      68 CNTR 0                    7/68
W   N  F07    39.0      7.0          ARMENTERO 68 HBC  0  SEE NOTE N ABOVE 11/68
W   N  F07    49.0      9.0          CONFORTO  68 HBC  0  SEE NOTE N ABOVE 11/68
W   C  P03    70.0     20.0          CONFORTO  69 HBC  0  SEE NOTE N ABOVE  9/69*

----------------  60  Y*0(1860) PARTIAL DECAY MODES  ----------------

                                                          DECAY MASSES
P1         Y*0(1860) INTO KBAR N                         497+ 939
P2         Y*0(1860) INTO SIGMA PI                      1189+ 139

----------------  60  Y*0(1860) BRANCHING RATIOS  -------------------

R1     Y*0(1860) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1         (J+1/2)X = 0.40           BUGG      68 CNTR 0                    7/68
R1  N, F07    0.12      0.02         ARMENTERO 68 HBC  0  SEE NOTE N ABOVE 11/68
R1  N  F07    0.10      0.04         CONFORTO  68 HBC  0  SEE NOTE.N ABOVE 11/68
R1  C  P03    0.21      0.03         CONFORTO  69 HBC  0  SEE NOTE C ABOVE  9/69*

R2     Y*0(1860) INTO SIGMA PI                          (P2)
R2   P     PROBABLY SEEN             GALTIERI  68 DBC  0  K-N TO SIG PI PI 11/68
R2   P   POSSIBLY THIS BUMP SEEN AT 1840+-10 MEV WITH A WIDTH OF 35+-10 MEV
R2     IS THE Y*0(1830), WHICH DECAYS STRONGLY TO SIGMA PI.  HOWEVER THE
R2     NARROW WIDTH HERE ARGUES FOR ITS BEING THE Y*0(1860).

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REFERENCES -- Y*0(1860)


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ARMENTER 67 NP B3 592          ARMENTEROS, F-LUZZI, + (CERN,HEICEL,SACLAY)IJP
     --  ARMENTEROS 67 IS REPLACED BY ARMENTEROS 68 AND CONFORTO 68.
ARMENTER 68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BUGG     68 PR 168 1466        +GILMORE, KNIGHT, + (RTHFRD,BRMNGHM,CVNDSH) I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
GALTIERI 68 PRL 21 573         BARBARO-GALTIERI, MATISON, +     (LRL,SLAC)
CONFORTO 69 LUND CONF PAPER    +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
     --  CONFORTO 69 VALUES  ARE QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CCNF          R LEVI SETTI  (RAPPORTEUR)          (CHICAGO)
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Λ(2015) F07

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27  Y*0(2015, JP=7/2+ ) I=0

A PARTIAL WAVE ANALYSIS OF THE SIGMA PI CHANNEL REQUI-
RES THE PRESENCE OF TWO STATES OF SAME J AND OPPOSITE P

SEE THE MINI-REVIEW AT START OF Y* LISTING

----------------  27  Y*0(2015)  MASS  (MEV)  ------------------------

M          (2015.)                   GALTIERI  69 HBC     SIG PI PAR.WAV.A 10/69*

----------------  27  Y*0(2015)  WIDTH (MEV)  ------------------------

W          (150.)                    GALTIERI  69 HBC     SIG PI PAR.WAV.A 10/69*

----------------  27  Y*0(2015)  PARTIAL DECAY RATES  ----------------

                                                          DECAY MASSES
P1         Y*0(2015) INTO KBAR N                         497+ 939
P2         Y*0(2015) INTO SIGMA PI                      1197+ 139

----------------  27  Y*0(2015)  BRANCHING RATICS  -------------------

R1         Y*0(2015) INTO (SIG PI)*(KBAR N)/TOTAL**2    (P2*P1)/TOTAL**2
R1            (.0256)                GALTIERI  69 HBC     SIGPI PAR.WAVE A 10/69*

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REFERENCES --Y*0(2015)


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GALTIERI 69 LUND PAPER 90      A BARBARO GALTIERI                     (LRL)IJP
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Data in parentheses have not been included in our averages.

Λ(2100) G_{07}

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41  Y*0(2100, JP=7/2-) I=0
WOHL 66 AND DAUM 68 FIND JP=7/2-.
SEE THE MINI-REVIEW AT START OF Y* LISTING

---------------- 41  Y*0(2100) MASS (MEV) ---------------------------

M        (2120.0)                  WOHL      66 HBC    K-P CH EX            7/66
M   B     2080.      10.           BURGUN    68 HBC   OK-P TO XI-K (B)     10/69*
M        (2120.)                   GALTIERI  69 HBC   O PART.WAVE SIG-PI   10/69*

 --B A RESCNANCE-LIKE EFFECT IS SEEN IN THIS REGION IN THE REACTION
    K-P TO XI K, BUT A PERHAPS MORE LIKELY EXPLANATION OF THE DATA IS
    IN TERMS OF A SO FAR OTHERWISE UNOBSERVED RESONANCE HAVING SPIN
    LESS THAN 7/2.  THE SITUATION REMAINS TO BE CLARIFIED.

---------------- 41  Y*0(2100) WIDTH (MEV) --------------------------

W        (145.0)                   WOHL      66 HBC                         7/66
W   B      80.       10.           BURGUN    68 HBC   DK-P TO XI-K (B)     10/69*
W         (40.)                    GALTIERI  69 HBC   O PART.WAVE SIG-PI   10/69*

---------------- 41  Y*0(2100) PARTIAL DECAY MODES ------------------

                                                      DECAY MASSES
P1        Y*0(2100) INTO KBAR N                        497+ 939
P2        Y*0(2100) INTO SIGMA PI                     1197+ 139
P3        Y*0(2100) INTO LAMBDA ETA                   1115+ 548
P4        Y*0(2100) INTO XI K                         1321+ 497
P5        Y*0(2100) INTO LAMBDA OMEGA                 1115+ 783
P6        Y*0(2100) INTO KBAR N PI                     497+ 939+ 139

---------------- 41  Y*0(2100) BRANCHING RATICS ------------------

R1        Y*0(2100) INTO (KBAR N)/TCTAL                (P1)/TOTAL
R1          (0.25)                 WOHL      66 HBC                         7/66

R2        Y*0(2100) INTO (SIG PI)*(KBAR N)/TOTAL**2   (P2*P1)/TOTAL**2
R2          (.0016)                GALTIERI  69 HBC     SIG PI PAR.WAV.A  10/69*

R3    Y*0(2100) INTO (LAMBDA ETA)*(KBAR N)/TOTAL**2    (P3)*(P1)/TOTAL**2
R3          (0.0087) OR LESS       FLATTE 2  67 HBC     K-P TO LAM ETA     6/68

R4    Y*0(2100) INTO (XI K)*(KBAR N)/TOTAL**2          (P4)*(P1)/TOTAL**2
R4          (0.0029)               TRIPP     67 RVUE                        8/67
R4   B        .0011     .0002      BURGUN    68 HBC     K-P TO XI K       11/68

R5        Y*0(2100) INTO (LAMBDA OMEGA)/TOTAL          (P5)/TOTAL
R5          (0.1)        OR LESS   FLATTE 1  67 HBC                         8/67

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                         REFERENCES -- Y*0(2100)

WOHL     66 PRL 17 107         C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
FLATTE 1 67 PR 155 1517        S M FLATTE                             (LRL)
TRIPP    67 NP B3 10           + LEITH, +    (LRL,SLAC,CERN,HEIDEL,SACLAY)
FLATTE 2 67 PR 163 1441        S M FLATTE, C G WOHL                   (LRL)
DAUM     68 NP B7 19           +ERNE, LAGNAUX, SENS, STEUER, UDC    (CERN)JP
BURGUN   68 NP B8 447          +MEYER,PAULI, +     (SACLAY,COLFRANCE,RTHFD)
GALTIERI 69 LUND PAPER 90      A BARBARO GALTIERI                     (LRL)IJP

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M > 2100 MEV – PRODUCTION AND σ_{TOTAL} EXPERIMENTS

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                   25  Y*0(2100)  PROD. EXPER.

                   SEE THE MINI-REVIEW AT START OF Y* LISTING

                   THE BUMP SEEN AT THIS MASS IN TOTAL CROSS SECTION EXPE.
                   CONTAINS BOTH THE G07 AND F07 STATES ABOVE-

---------------- 25  Y*0(2100)  MASS  (MEV) -PROD. EXP. ---------------

M        (2097.0)    (6.0)              BOCK      65 HBC    PBAR P 5.7 BEV/C  7/66
M         2103.0     10.0               KYCIA     67 CNTR   K-P, D TOTAL      8/67
M         2100.0      7.0               BUGG      68 CNTR   K-P, D TOTAL      6/68
M         . . . . . . . . . . .
M   AVG   2101.0      5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

---------------- 25  Y*0(2100)  WIDTH (MEV) -PROD. EXP. ---------------

W          (24.0)   (14.0)   (24.0)  BOCK      65 HBC    INTO KBAR N (PI)  7/66
W          143.0     10.0            KYCIA     67 CNTR                     8/67
W          140.0     15.0            BUGG      68 CNTR                     6/68
W         . . . . . . . . . . .
W   AVG    142.1      8.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

---------------- 25  Y*0(2100)  BRANCHING RATIOS -PROD. EXP. ----------

R1        Y*0(2100) INTO (KBAR N)/TOTAL                 PROD. EXP.
R1           0.333    0.013          KYCIA     67 CNTR                     8/67
R1          (0.305)                  BUGG      68 CNTR                     6/68

R2        Y*0(2100) INTO (KBAR N PI)/TOTAL              PROD. EXP.
R2               SEEN                BOCK      65 HBC

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                         REFERENCES --Y*0(2100)

BOCK     65 PL 17 166          +COOPER,FRENCH,KINSON, +      (CERN,SACLAY)
COOL     66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  SLIGHTLY REVISED RESULTS FRCM KYCIA 67 REPLACE COOL 66 --
KYCIA    67 PRIVATE COMM.      T F KYCIA                              (BNL) I
BUGG     68 PR 168 1466        +GILMORE,KNIGHT, +     (RTHFD,BRMGHM,CVNDSH) I

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Λ(2350)

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42  Y*0(2350, JP=     ) I=0
SEE THE MINI-REVIEW AT START OF Y* LISTING
 DAUM 68 FAVORS JP=7/2- OR 9/2+.

---------------- 42  Y*0(2350) MASS (MEV) ---------------------------

M         2352.0     11.0           KYCIA     67 CNTR   K-P, D TOTAL       8/67
M         2340.0      7.0           BUGG      68 CNTR   K-P, D TOTAL       6/68
M         . . . . . . . . . . .
M   AVG   2343.5      5.9     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

---------------- 42  Y*0(2350) WIDTH (MEV) -------------------------

W          210.0     50.0           KYCIA     67 CNTR                      8/67
W          140.0     20.0           BUGG      68 CNTR                      6/68
W         . . . . . . . . . . .
W   AVG    149.7     24.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

---------------- 42  Y*0(2350) PARTIAL DECAY MODES ----------------

                                                      DECAY MASSES
P1        Y*0(2350) INTO KBAR N                         497+ 939

---------------- 42  Y*0(2350) BRANCHING RATIOS -------------------

R1        Y*0(2350) INTO (KBAR N)/TOTAL                (P1)/TOTAL
    J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(KBAR N)/TOTAL
R1          0.68      0.10          KYCIA     67 CNTR                      8/67
R1         (0.57)                   BUGG      68 CNTR                      6/68

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                         REFERENCES -- Y*0(2350)

COOL     66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA    67 PRIVATE COMM.      T F KYCIA                              (BNL) I
BUGG     68 PR 168 1466        +GILMORE,KNIGHT, +     (RTHFD,BRMGHM,CVNDSH) I
DAUM     68 NP B7 19           +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP

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              END - PRODUCTION OR TCTAL CRCSS SECTION DATA

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Σ^+

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19  SIGMA +   (1189,JP=1/2+)  I=1
SEE LISTINGS OF STABLE PARTICLES

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Σ^-

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20  SIGMA -   (1198,JP=1/2+)  I=1
SEE LISTINGS OF STABLE PARTICLES

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Σ^0

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21  SIGMA 0   (1193,JP=1/2+)  I=1
SEE LISTINGS OF STABLE PARTICLES

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Σ(1385) P_{13}

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43  Y*1(1385, JP=3/2+) I=1
 FOR DISCUSSION OF INCONSISTENCY OF ERRORS AND OUR
 MODIFICATIONS, SEE NOTE ON K*(890)

 FOR THE TABLES WE USE ONLY THE UNSTARRED DATA, WHICH
 ATTEMPTS TO OBTAIN THE SEPARATE CHARGE-STATE MASSES AN
 WIDTHS.  SEE HOWEVER THE IDEOGRAMS INSERTED IN LISTING
THESE INDICATE SERIOUS SYSTEMATICS, PERHAPS ARISING FROM INTERFERENCE E
FECTS THAT CHANGE WITH PRODUCTION MECHANISM AND BEAM MOMENTUM.

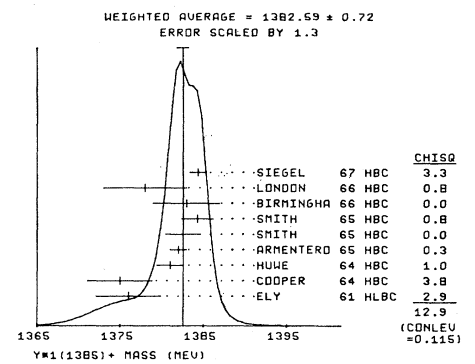
---------------- 43  Y*1(1385) MASS (MEV) ---------------------------

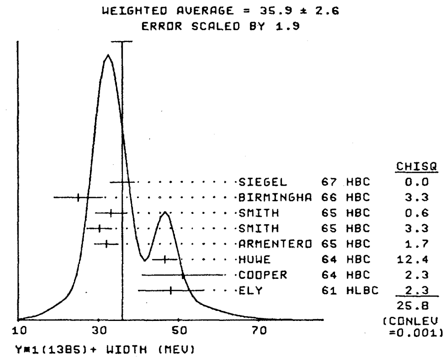
M        141(1384.0)                 ALSTON    60 HBC  +- K-P 1.15 BEV/C
M         38(1384.0)                 MARTIN    61 HBC  0+ K20 P .98 BEV/C
M           (1385.0)                 BERGE     61 HBC  +- K-P .4-.85 BEV/C
M           (1392.0)    (7.0)        COLLEY    62 HLBC 0- PI- PRP 2. BEV/C
MO       106(1381.0)    (4.0)        CURTIS    63 OSPK 0  PI-P 1.5 BEV/C
M           (1392.0)   (10.0)        MUSGRAVE  65 HBC  +-0PBAR P 3-4 BEV/C  7/66
M           (1389.0)    (3.0)        BALTAY    65 HBC  +- PBAR P 3.7 BEV/C  7/66

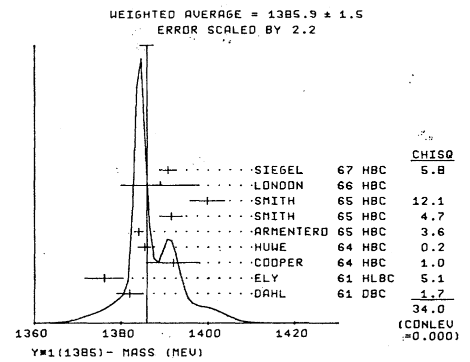
M+   E 154 1376.0      3.9           ELY       61 HLBC + K-P 1.11 BEV/C
M+   E             ERROR OF 3.0 ENLARGED TO 3.9 BY US,BECAUSE LT STATIST.ERR. 10/69*
M+     170 1375.0      3.9           COOPER    64 HBC  +  K-P 1.45 BEV/C
M+     859 1381.0      1.6           HUWE      64 HBC  +  K-P 1.22 BEV/C
M+     750 1382.0      1.0           ARMENTERO 65 HBC  +  K-P .9-1.2 BEV/C
M+   S 250 1382.6      2.1           SMITH     65 HBC  +  K-P 1.95 BEV/C    9/66
M+   S 250 1384.3      1.9           SMITH     65 HBC  +  K-P 1.8 BEV/C     9/66
M+   S             ERROR OF 1.4 ENLARGED TO 2.1 BY US,BECAUSE LT STATIST.ER.  10/69*
M+   S             ERROR OF 1.1 ENLARGED TO 1.9 BY US,BECAUSE LT STATIST.ER.  10/69*
M+   B  40 1383.0      4.0           BIRMINGHA 66 HBC   +  3.5 K- P         9/67
M+   B             ERROR OF 2.0 ENLARGED TO 4.0 BY US,BECAUSE LT STATIST.ERR. 10/69*
M+         1378.0      5.0           LONDON    66 HBC  +  K-P 2.24 BEV/C    7/66
M+    1260 1384.4      1.0           SIEGEL    67 HBC  +  K-P AT 2.1 GEV/C 10/69*
M+         . . . . . . . . . . .
M+   AVG   1382.59     0.72    AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 1.3)
                       (SEE IDEOGRAM BELOW )
M-      93 1382.0      3.0           DAHL      61 DBC  -  K-D 0.45 BEV/C
M-   E 224 1376.0      4.4           ELY       61 HLBC -
M-   E             ERROR OF 3.0 ENLARGED TO 4.4 BY US,BECAUSE LT STATIST.ERR. 10/69*
M-     200 1392.0      6.2           COOPER    64 HBC  -
M-    1086 1385.3      1.5           HUWE      64 HBC  -
M-    1380 1384.0      1.0           ARMENTERO 65 HBC  -
M-   S 120 1391.5      2.6           SMITH     65 HBC  -  K-P 1.8 BEV/C     9/66
M-   S  58 1399.8      4.0           SMITH     65 HBC  -  K-P 1.95 BEV/C    9/66
M-   S             ERROR OF 1.8 ENLARGED TO 2.6 BY US,BECAUSE LT STATIST.ER.  10/69*
M-   S             ERROR CF 1.4 ENLARGED TO 4.0 BY US,BECAUSE LT STATIST.ER.  10/69*
M-         1389.0      9.0           LONDON    66 HBC  -                    7/66
M-     370 1390.7      2.0           SIEGEL    67 HBC  -  K-P AT 2.1 GEV/C 10/69*
M-         . . . . . . . . . . .
M-   AVG   1385.9      1.5     AVERAGE (ERRCR INCLUDES SCALE FACTOR OF 2.2)
                       (SEE IDEOGRAM BELOW )
```

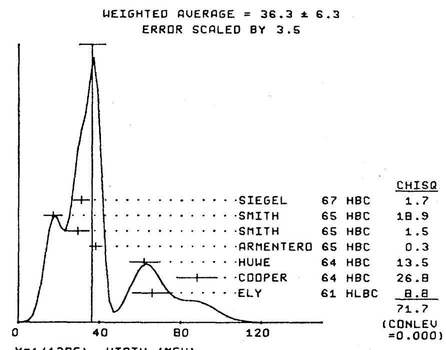
See the illustrative key preceding the data card listings.

Data in parentheses have not been included in our averages.









43 Y*(-) - Y*(+) MASS DIFFERENCE (MEV)

D	R	(0.0)	(4.2)	ELY	61	HLBC	+-	K-P 1.11 BEV/C	8/66
D	R	(17.)	(7.)	COOPER	64	HBC			10/69*
D	R	(4.3)	(2.2)	HUWE	64	HBC	+-	K-P 1.22 BEV/C	8/66
D	R	(2.0)	(1.5)	ARMENTERO	65	HBC	+-	K-P .9-1.2 BEV/C	8/66
D	R	(7.2)	(2.1)	SMITH	65	HBC	+-	K-P 1.8 BEV/C	9/66
D	R	(17.2)	(2.0)	SMITH	65	HBC	+-	K-P 1.95 BEV/C	9/66
	R	REDUNDANT WITH DATA IN MASS LISTING.							
D	R	(11.0)	(9.0)	LONDON	66	HBC	+-	K-P 2.24 BEV/C	8/66
D		9.0	6.0	LONDON	66	HBC	+-	LAMBDA 3 PI EVTS	7/66
D	R	(6.3)	(2.0)	SIEGEL	67	HBC		K-P AT 2.1 GEV/C	10/69*

43 Y*1(1385) WIDTH (MEV)

W		(64.0)		ALSTON	60	HBC	+-		
W		(20.0)	OR LESS	MARTIN	61	HBC	0+		
W		(40.0)		BERGE	61	HBC	+-		
W		(80.0)	(10.0)	COLLEY	62	HLBC	0-		
W		(30.0)	(9.0)	CURTIS	63	OSPK	0		
W		(38.0)	(9.0)	MUSGRAVE	65	HBC	+-0		7/66
W		(26.0)	(5.0)	BALTAY	65	HBC	+-		7/66
W+		48.0	8.0	ELY	61	HLBC	+		
W+		51.0	10.0	COOPER	64	HBC	+		
W+		46.5	3.0	HUWE	64	HBC	+		
W+		32.0	3.0	ARMENTERO	65	HBC	+		
W+		30.3	3.1	SMITH	65	HBC	+	K-P 1.8 BEV/C	9/66
W+		33.1	3.8	SMITH	65	HBC	+	K-P 1.95 BEV/C	9/66
W+	40	25.0	6.0	BIRMINGHA	66	HBC	+	3.5 K- P	9/67
W+	1260	36.0	3.0	SIEGEL	67	HBC		K-P AT 2.1 GEV/C	10/69*
W+		. . . . .	. . . . .						
W+	AVG	35.9	2.6	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.9) (SEE IDEOGRAM BELOW)					
W-		(40.0)		DAHL	61	DBC	-		
W-		66.0	10.0	ELY	61	HLBC	-		
W-		88.0	10.0	COOPER	64	HBC	-		
W-		62.0	7.0	HUWE	64	HBC	-		
W-		38.0	3.0	ARMENTERO	65	HBC	-		
W-		29.2	5.7	SMITH	65	HBC	-	K-P 1.80 BEV/C	9/66
W-		17.1	4.4	SMITH	65	HBC	-	K-P 1.95 BEV/C	9/66
W-	370	31.0	4.0	SIEGEL	67	HBC		K-P AT 2.1 GEV/C	10/69*
W-		. . . . .	. . . . .						
W-	AVG	36.3	6.3	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5) (SEE IDEOGRAM BELOW)					

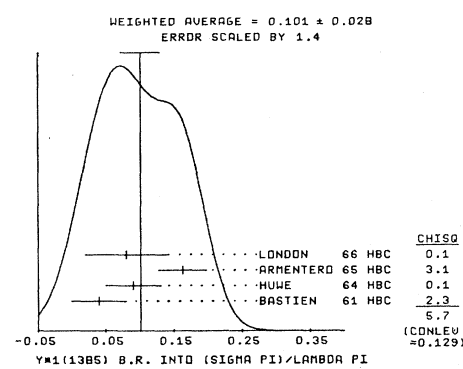
43 Y*1(1385) PARTIAL DECAY MODES

		DECAY MASSES
P1	Y*1(1385) INTO LAMBDA PI	1115+ 139
P2	Y*1(1385) INTO SIGMA PI	1197+ 139

43 Y*1(1385) BRANCHING RATIOS

R1 Y*1(1385) INTO (SIGMA PI)/(LAMBDA PI) (P2)/(P1)

R1		0.04	0.04	BASTIEN	61	HBC	+-	
R1		(0.04)	OR LESS	ALSTON	62	HBC	+-0	
R1		0.09	0.04	HUWE	64	HBC	+-	
R1		0.163	0.035	ARMENTERO	65	HBC	+-	7/66
R1		0.08	0.06	LONDON	66	HBC	+	7/66
R1		. . . . .	. . . . .					
R1	AVG	0.101	0.028	AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4) (SEE IDEOGRAM BELOW)				



See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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                              REFERENCES -- Y*1(1385)

ALSTON   60 PRL 5 520          +ALVAREZ,EBERHARD,GOOD,GRAZIANO, +    (LRL) I
DAHL     61 PRL 6 142          +HORWITZ,MILLER,MURRAY,WHITE          (LRL)
MARTIN   61 PRL 6 283          +LEIPUNER,CHINOWSKY,SHIVELY, +   (BNL,YALE)
BERGE    61 PRL 6 557          +BASTIEN,DAHL,FERRO-LUZZI,KIRZ, +     (LRL)
BASTIEN  61 PRL 6 702          P BASTIEN,M FERRO-LUZZI,A H ROSENFELD (LRL)
ELY      61 PRL 7 461          +FUNG,GIDAL,PAN,POWELL,WHITE          (LRL) J

ALSTON   62 CERN CONF 311      +ALVAREZ,FERRO-LUZZI,ROSENFELD, +     (LRL)
COLLEY   62 PR 128 1930        +GELFAND,NAUENBERG, +    (COLUMBIA,RUTGERS) JP
CURTIS   63 PR 132 1771        +COFFIN,MEYER,TERWILLIGER            (MICH) J
COOPER   64 PL 8 365           +FILTHUTH,FRIDMAN,MALAMUD, +   (CERN,AMSTR)
HUWE     64 UCRL-11291 THESIS D O HUWE                               (LRL) JP
  ALSO   69 PR 180 1824        D O HUWE                              (LRL)

MUSGRAVE 65 NC 35 735          +PETMEZAS,+ (BIRMGHM,CERN,EP,IMPCOL,SACLAY)
ARMENTER 65 PL 19 75           ARMENTEROS, +           (CERN,HEIDEL,SACLAY)
BALTAY   65 PR 140 B1027       +SANDWEISS,TAFT,CULWICK,KOPP, +  (YALE,BNL)
SMITH    65 THESIS (UCLA)      L T SMITH                            (UCLA)

BIRMINGH 66 PR  152  1148      BIRMINGHAM,GLASGOW,I.C., OXFORDYRUTHERFORD
LONDON   66 PR 143 1034        +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL,SYCR) J
SIEGEL   67 UCRL 18041 THESIS D M SIEGEL                             (LRL)

          QUANTUM NUMBER DETERMINATICNS NCT REFERRED TO IN DATA CARDS.

SHAFER   64 PR 134 B1372       J B SHAFER, D O HUWE                  (LRL) JP
MALAMUD  64 PL 10 145          E MALAMUD, P E SCHLEIN          (CERN,UCLA) JP

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M < 1500 MEV – PRODUCTION EXPERIMENTS

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Σ(1440)

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80  Y*1(1440, JP=     ) I=1

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

CLINE 68 FIND A NARROW PEAK AT 1440 MEV (JUST ABOVE
THE KBAR N THRESHOLD) IN THE LAMBDA PI INVARIANT MASS
FOR K- D TO LAMBDA PI- P EVENTS.  THEY DISCUSS ALTER-
NATE INTERPRETATIONS -- THAT IT IS A RESONANCE OR A KINEMATIC EFFECT.
IN CLINE 68 THE K- BEAM MOMENTUM IS 0.4 GEV/C.  IN A STUDY OF THE SAME
REACTION WITH A MOMENTUM OF 1.1 GEV/C, ALEXANDER 69 FIND NO PEAK.  IN
ADDITION, THEY ARE ABLE TO EXPLAIN THE RESULTS OF BOTH EXPERIMENTS
WITHOUT INVOKING A NEW RESONANCE.

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                              REFERENCES -- Y*1(1440)

CLINE    68 PRL 21 1372        D CLINE, R LAUMANN, J MAPP      (WISCONSIN) I
ALEXANDE 69 PRL 22 483         ALEXANDER, HALL, JEW, +      (LRL,RIVERSIDE)

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Σ(1480)

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23  Y*1(1480, JP=     ) I=1

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

PEAKS ARE SEEN IN LAMBDA PI AND SIGMA PI SPECTRA IN
THE REACTION PI+P TO K+ PI Y AT 1.7 GEV/C.  ALSO THE
Y POLARIZATION OSCILLATES IN THE SAME REGION.  SPIN-
CONFIRMATION OF THIS RESONANCE IS REQUIRED.

----------------  23  Y*1(1480) MASS (MEV)    --------------------------

M          1480.0    15.0          YU-LI PAN 69 HBC  +  PI+P TO K PI LAM  9/69*
M          1465.0    20.0          YU-LI PAN 69 HBC  +  PI+P TO K PI SIG  9/69*
M          . . . . . . . . . .
M   AVG    1474.6    12.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  23  Y*1(1480) WIDTH (MEV)    -------------------------

W          (35.0)                  YU-LI PAN 69 HBC  +  PI+P TO K PI LAM  9/69*
W          (25.0)                  YU-LI PAN 69 HBC  +  PI+P TO K PI SIG  9/69*

----------------  23  Y*1(1480) PARTIAL DECAY MODES    -----------------

                                                         DECAY MASSES
P1         Y*1(1480) INTO KBAR N                         497+ 939
P2         Y*1(1480) INTO LAMBDA PI                      1115+ 139
P3         Y*1(1480) INTO SIGMA PI                       1189+ 139

----------------  23  Y*1(1480) BRANCHING RATIOS       -----------------

R1     Y*1(1480) INTO (SIGMA PI)/(LAMBDA PI)             (P3)/(P2)
R1            0.72      0.49       YU-LI PAN 69 HBC  +                    9/69*

R2         Y*1(1480) INTO (PROTON KOBAR)/(LAMBDA PI)    (P1)/(P2)
R2            0.36      0.25       YU-LI PAN 69 HBC  +                    9/69*

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                              REFERENCES -- Y*1(1480)

YU-LI PA 69 PRL 23 806         YU-LI PAN, F L FORMAN                (PENN) I
YU-LI PA 69 PRL 23 808         YU-LI PAN, F L FORMAN                (PENN) I

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                     END  PRODUCTION EXPERIMENTS
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Σ(1560) — P'_{11}

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79  Y*1(1560, JP=1/2+) I=1

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THE PARTIAL-WAVE ANALYSIS OF K- N TO SIGMA PI SUGGESTS
SUCH A RESONANCE, BUT FURTHER EVIDENCE IS REQUIRED.

----------------  79  Y*1(1560) MASS (MEV)    --------------------------

M          (1560.0)                ARMENTERO 69 HDBC 0- K-N TO SIGPI EI   9/69*

----------------  79  Y*1(1560) WIDTH (MEV)    -------------------------

W          (100.0)                 ARMENTERO 69 HDBC 0-                   9/69*

----------------  79  Y*1(1560) PARTIAL DECAY MODES    -----------------

                                                         DECAY MASSES
P1         Y*1(1560) INTO KBAR N                         497+ 939
P2         Y*1(1560) INTO SIGMA PI                       1197+ 139

----------------  79  Y*1(1560) BRANCHING RATIOS     -------------------

R1     Y*1(1560) INTO (KBAR N)*(SIGMA PI)/TOTAL**2      (P1*P2)/TOTAL**2
R1          (0.04)                 ARMENTERO 69 HDBC                      9/69*

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                              REFERENCES -- Y*1(1560)

ARMENTER 69 LUND PAPER 224    ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
    --  ARMENTEROS 69 VALUES  ARE QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CONF          R LEVI SETTI  (RAPPORTEUR)        (CHICAGO)

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Σ(1620)

Note on Σ (1620)

The major evidence for this state comes from an experiment of a BNL-CCNY collaboration. Their latest results, CRENNELL 69, are based on a four-fold increase in the data of CRENNELL 68. The reaction in question is $K^- n \to \Sigma(1620) + \pi + \pi$ at 3.9 GeV/c with subsequent decay of Σ (1620) into $\Lambda\pi$. The enhancement remains with no increase in statistical significance. The SABRE collaboration has presented at the Lund Conference a comparable amount of data in the same reaction at 3.0 GeV/c. They do not see the enhancement of CRENNELL 69; on the contrary, they believe it to be a spurious peak resulting from misidentified Σ^0 from the production of $\Sigma(1660)^{\pm}$, then decaying into $\Sigma^0\pi^{\pm}$. The BNL-CCNY group, however, give further arguments that this cannot be, so the controversy goes on.

Formation experiments do not report this state, which could be consistent with a low elasticity. The BNL-CCNY group report a low $\bar{K}N$ branching ratio, but also very small branching ratios in the other channels. This is quite inconsistent with SU(3) (TRIPP 69).

In conclusion, the situation is now confused enough that we have decided to take this state off the Baryon Table and keep it in the listing until further clarification.

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78  Y*1(1620, JP=     ) I=1.

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS,
AND MINI-REVIEW ABOVE.

THIS RESONANCE NEEDS CONFIRMATION.  THE RESULTS OF
CRENNELL 69 AT 3.9 GEV/C ARE NOT CONFIRMED BY THE SABRE
COLLABORATION AT 3.0 GEV/C (SABRE 69). PARTIAL WAVE
ANALYSIS OF ARMENTEROS 69 DOES NOT CONFIRM IT NOW .

----------------  78  Y*1(1620) MASS (MEV)    --------------------------

M  N     (1616.0)    (8.0)          CRENNELL  68 DBC  +- K-D 3.9 BEV/C    11/68
   N   EVENTS OF CRENNELL 68 ARE IN THE LARGER SAMPLE OF CRENNELL 69.
M  A     (1610.0)                   ARMENTERO 68 HDBC 0- KBAR N TO LAM PI 11/68
M  A      ANALYSIS OF OLD+NEW DATA AT LOWER ENERGY DOES NOT SHOW A P11 RE.  3/69*
M       20 1618.0     3.0           BLUMENFEL 69 HBC  +  KO LONG + PROTON  9/69*
M          1619.0     8.0           CRENNELL  69 DBC  +- K-N TO LAM 3 PI   9/69*
M          . . . . . . . . . . .
M  AVG     1618.1     2.8      AVERAGE (ERRCR,INCLUDES SCALE FACTOR OF 1.0)
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Data in parentheses have not been included in our averages.

```
----------------   78  Y*1(1620) WIDTH (MEV)   --------------------------

W   N       (66.0)   (16.0)            CRENNELL  68 DBC  +- SEE NCTE N ABOVE 11/68
W   A       (60.0)                     ARMENTERO 68 HDBC O-                  11/68
W      20   30.0      10.0             BLUMENFEL 69 HBC  +                   9/69*
W           72.0      22.0     15.0    CRENNELL  69 DBC  +-                  9/69*
W         . . . . . . . . . .
W   AVG     39.5      17.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.0)
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------   78  Y*1(1620) PARTIAL DECAY MODES   -----------------

                                                          DECAY MASSES
P1        Y*1(1620) INTO KBAR N                          497+ 939
P2        Y*1(1620) INTO LAMBDA PI                      1115+ 139
P3        Y*1(1620) INTO Y*1(1385) PI                   1385+ 139
P4        Y*1(1620) INTO LAMBDA PI PI                   1115+ 139+ 139

----------------   78  Y*1(1620) BRANCHING RATIOS   --------------------

R1     Y*1(1620) INTO (KBAR N)*(LAMBDA PI)/TOTAL**2      (P1*P2)/TOTAL**2
R1  A        (0.0225)               ARMENTERO 68 HDBC O- SOLUTION B          9/69*

R2     Y*1(1620) INTO (KBAR N)/(LAMBDA PI)               (P1)/(P2)
R2           (0.0)    (0.1)         CRENNELL  68 DBC  +

R3     Y*1(1620) INTO LAMBDA PI                          (P2)
R3             LARGE                CRENNELL  68 DBC  +-                     11/68

R4     Y*1(1620) INTO (Y*1(1385) PI)/(LAMBDA PI)         (P3)/(P2)
R4           (0.2)    (0.1)         CRENNELL  68 DBC  +-                     11/68

R5     Y*1(1620) INTO (LAMBDA PI PI)/(LAMBDA PI)         (P4)/(P3)
R5      14   (2.5)  APPROX          BLUMENFEL 69 HBC  +                      9/69*

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                            REFERENCES -- Y*1(1620)
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CRENNELL 68 PRL 21 648          +DELANEY, FLAMINIO, KARSHON, +   (BNL,CCNY) I
ARMENTER 68 NP B8 183           ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENTER 69 LUND  PAPER 227     ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
BLUMENFE 69 PL 29B 58           BLUMENFELD, KALBFLEISCH              (BNL) I
CRENNELL 69 LUND PAPER 183      +KARSHON, LAI, ONEIL, SCARR, +   (BNL,CCNY) I
    --  CRENNELL 69 AND ARMENTEROS 69 RESULTS ARE QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CONF           R LEVI SETTI     (RAPPORTEUR)         EFINS
SABRE    69  LUND PAPER 256     SABRE COLLABOR.  (SACL+AMST+BGNA+REHO+EPOL)
TRIPP    69 UCRL 19361          R D TRIPP                             (LRL)

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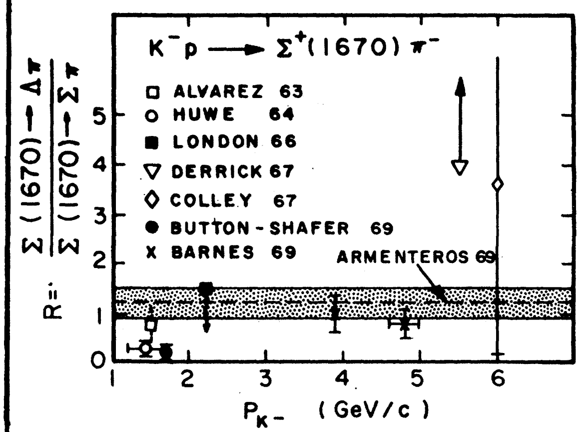
Note on the 1660-MeV Region, I = 1

Formation experiments show the presence of only one I = 1 state in this energy region with major decay modes into: $\overline{K}N$ (8%), $\Lambda\pi$(32%), $\Sigma\pi$(50%). Its quantum numbers are $J^P = 3/2^-$.

Production experiments are quite confused: as for the quantum numbers it is now agreed that $J^P = 3/2^-$ is the most likely; the branching ratios, especially $R = \Lambda\pi/\Sigma\pi$, however, do not agree among the various experiments. EBERHARD 69 see the $R' = \Sigma\pi/\Sigma\pi\pi$ ratio change with the momentum transfer to the proton and suggest the existence of two Y_1^* with the same mass and same quantum numbers.

In the past we have included in the Baryon Table two states $\Sigma(1660)$, $\Sigma(1690)$, with the comment that the decay modes of the two states were not separated yet. The evidence for $\Sigma(1690)$ came from K^-p experiments at high energy (4.6 to 6 GeV/c) where the ratio R seemed to be very large, in disagreement with the data at lower energy. Recently, however, BARNES 69 presented improved data of the PRIMER 67 experiment and now find a branching ratio in agreement with formation experiments.

The accompanying figure shows a plot (taken from BARNES 69) of all the measurements of the $\Lambda\pi/\Sigma\pi$ ratio. The evidence for a large ratio [the effect that was evidence for $\Sigma(1690)$] is now based on experiments with small statistics. The mass shift of 20 to 40 MeV does not seem to us to be evidence for a new state. We withdraw $\Sigma(1690)$ from the table, waiting for better evidence for it. Still unexplained is the small value of R at low incident K^- energy and the variation of R' with momentum transfer.



The branching ratio $R = \dfrac{\Sigma(1670) \rightarrow \Lambda\pi}{\Sigma(1670) \rightarrow \Sigma\pi}$ versus incident K^- momentum for the various experiments, as plotted by BARNES 69. DERRICK 67 and COLLEY 67 claim the existence of a different state, $\Sigma(1690)$, because of their large values of R. The value of R from the formation experiment of ARMENTEROS 69 is in agreement with most of the production experiment results.

Σ(1670)

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44  Y*1(1670, JP=3/2-) I=1     D13

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

SEE NOTE ABOVE

 WELL ESTABLISHED RESONANCE.  IT HAS BEEN SEEN IN BOTH
 FORMATION AND PRODUCTION EXPERIMENTS.  HOWEVER THE
 BRANCHING RATIOS OBTAINED BY THESE TWO METHODS SHOW
 LARGE INCONSISTENCIES.

       SEE LISTING OF PRODUCTION EXPERIMENTS BELOW

     AS FOR THE QUANTUM NUMBERS, THE ANALYSES OF LAMBDA PI CHANNEL (IN
FORMATION EXP.) AND Y*0(1405)+PI CHANNEL (IN PROD. EXP.) ARE CONSISTENT
WITH JP=3/2-.

----------------   44  Y*1(1670) MASS (MEV)   -------------------------

M         (1660.0)                   BERLEY    64 HBC  O  K-P TO LAM PIO    7/66
M   S     (1668.)     (5.)           ARMENTER  68 HBC   O K-P ELAS.+CH.EX  11/68
M         (1667.)                    ARMENTE1  68 HBC    OK-P TO LAM.PI EI 11/68
M         (1661.0)    (2.0)          ARMENTE2  68 HBC   O  K-P TO SIGMA PI 11/68
M         (1680.)                    ARMENTE4  69 DBC     K-N TO SIG- PIO  12/68*
M   S     (1663.0)    (2.0)          ARMENT-5  69 HBC  O  K-P TC SIGMPI EO  9/69*
M   S  SYSTEMATIC ERROR NOT INCLUDED . ONLY INDETERM. IN FIT QUOTED         6/68
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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----------------   44  Y*1(1670) WIDTH (MEV)   ---------------------------

W            (60.0)                   BERLEY    64 HBC  0                 7/66
W   S        (56.)     (18.)          ARMENTER  68 HBC   0 K-P ELAS.+CH.EX  11/68
W            (50.)                    ARMENTE1  68 HBC   0 K-P TO LAMB.PI  11/68
W            (44.0)     (4.0)         ARMENTE2  68 HBC   0 K-P TO SIGMA PI  11/68
W            (47.0)                   ARMENTE4  69 DBC     K-N TO SIG- PI0  12/68*
W   S        (49.0)     (4.0)         ARMENT-5  69 HBC  0  K-P TO SIGMPI ED  9/69*
W   S  SYSTEMATIC ERROR NOT INCLUDED . ONLY INDETERM. IN FIT QUOTED        6/68

----------------   44  Y*1(1670) PARTIAL DECAY MODES   ------------------

                                                          DECAY MASSES
P1         Y*1(1670) INTO KBAR N                          497+ 939
P2         Y*1(1670) INTO LAMBDA PI                      1115+ 139
P3         Y*1(1670) INTO SIGMA PI                       1197+ 139
P4         Y*1(1670) INTO LAMBDA PI PI                   1115+ 139+ 139
P5         Y*1(1670) INTO SIGMA PI PI                    1197+ 139+ 139
P6         Y*1(1670) INTO Y*1(1385) PI                   1385+ 139
P7         Y*1(1670) INTO Y*0(1405) PI                   1405+ 139

----------------   44  Y*1(1670) BRANCHING RATIOS   -------------------

R1         Y*1(1670) INTO (KBAR N)/TOTAL                 (P1)/TOTAL
R1           (0.09)    (0.02)         ARMENTER  68 HBC                    9/69*
R1            0.08      0.02          ARMENT-5  69 HBC  0  ELAS. +CH.EX. ED  9/69*

R2         Y*1(1670) INTO (LAMBDA PI PI)/TOTAL           (P4)/TOTAL
R2           (0.11)       OR LESS     ARMENTE3  68 HBC    K-P (P1=.09)     9/69*

R3         Y*1(1670) INTO (SIGMA PI PI)/TOTAL            (P5)/TOTAL
R3   A       (0.14)    OR  LESS       ARMENTE3  68 HBC    K-P AND D-P1=.09 11/68
R3   A   RATIO ONLY FOR (SIG2PI) SYSTEM IN I=1, WHICH CANNOT BE Y*1(1385)     11/68

R4         Y*1(1670) INTO (Y*0(1405) PI)/TOTAL           (P7)/TOTAL
R4           (0.06)    OR  LESS       ARMENTE3  68 HBC    K-P AND D-P1=.09 11/68

R5      Y*1(1670) INTO (LAMBDA PI)*(KBAR N)/TOTAL**2     (P2*P1)/TOTAL**2
R5           (0.0256)                 ARMENTE1  68 HBC   0 K-P TO LAMB.PI  11/68

R6      Y*1(1670) INTO (SIGMA PI)*(KBAR N)/TOTAL**2      (P3*P1)/TOTAL**2
R6           (0.044)   (.004)         ARMENTE2  68 HBC   0 OLD DATA        11/68
R6           (0.029)                  BERLEY    68 HBC   0 K-P .6-.82 BEV/C 11/68
R6           (0.036)                  ARMENTE4  69 DBC                    9/69*
R6            0.04      0.004         ARMENT-5  69 HBC  0  NEW DATA        9/69*

R7      Y*1(1670) INTO Y*1(1385)*(KBAR N)/TOTAL**2       (P6*P1)/TOTAL**2
R7           (0.031)  (0.006)         SIMS      68 DBC   -                 11/68

R8      Y*1(1670) INTO (Y*0(1405) PI)/(SIG PI)           (P7)/(P3)
R8           (0.5)    OR LESS         BERLEY    68 HBC   0 K-P .6-.82 BEV/C 11/68

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                         REFERENCES -- Y*1(1670)

BERLEY   64 DUBNA CONF I 565  +CONNOLLY,HART,RAHM,STONEHILL, +      (BNL)IJP

ARMENTER 68 NP B8 195         ARMENTEROS,BAILLON +      (CERN+HEID+SACLAY)IJP
ARMENTE1 68 NP B8 183         ARMENTEROS,BAILLON +      (CERN+HEID+SACLAY)IJP
ARMENTE2 68 NP B8 223         ARMENTEROS+BAILLON +     (CERN+HEIDE+SACLAY)IJP
ARMENTE3 68 PL 28B 521        ARMENTEROS,BAILLON +      (CERN+HEID+SACLAY)I

BERLEY   68  VIENNA CONF      BERLEY,HART,RAHM,WILLIS,YAMAMOTO      (BNL)
SIMS     68 PRL 21 1413       SIMS,ALBRIGHT,BARTLEY,MEER+ (FLO+TAFTS+BRA)
ARMENTE4 69 NP B10 459        ARMENTEROS,BAILLON,MINTEN +   (CERN+SACLAY) J
ARMENT-5 69 NP (SUB)CERN 69-13ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP

                  PAPERS NOT REFERRED TO IN DATA CARDS.

BASTIEN1 63 PRL 10 188        P L BASTIEN, J P BERGE              (LRL) IJ
      --  REPLACED BY BASTIEN 2, BUT SIMILAR AND MORE READILY AVAILABLE.
BASTIEN2 63 UCRL-10779 THESIS P L BASTIEN                         (LRL) IJ
SMART    66 PRL 17 556        W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
ARMENTER 67 NP B3 592         ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)

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Σ(1670) PRODUCTION EXPERIMENTS

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                  SEE NOTE PRECEDING Y*1(1670)

----------------   44 Y*1(1670) MASS  (MEV) -----PRODUCTION --------------

M         (1685.0)                    ALEXANDER 62 HBC  0- PI-P 2-2.2 BEV/C
M          1660.0      10.0           ALVAREZ   63 HBC  + K-P 1.51 BEV/C
M         (1665.0)     (5.0)          BUGG      68 CNTR   K-P, 0 TOTAL C.S
M    P   70(1661.)     (9.)           PRIMER    68 HBC  + K-P 4.6-5. GEV/C  7/68
M    P    SEE BARNES 69 FOR NEW ANALYSIS OF DATA (3 TIMES MORE DATA)       10/69*
M          1689.       15.            BARNES    69 HBC  + LAM.PI -5 GEV/C  10/69*
M          1670.       10.            BARNES    69 HBC  + K-P TO SIG PI    10/69*
M          1677.       20.            BARNES    69 HBC  + LAM.PI -3.9GEV/C 10/69*
M          . . . . . . . . .
M    AVG   1670.1       6.1    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------   44 Y*1(1670) WIDTH (MEV) -----PRODUCTION --------------

W          (45.0)                     ALEXANDER 62 HBC  0-
W           40.0       10.0           ALVAREZ   63 HBC  +
W          (30.0)     (15.0)          BUGG      68 CNTR                    11/66
W    P   70 (60.)     (20.)           PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68
W           110.       20.            BARNES    69 HBC  +  K-P TO SIG PI    10/69*
W           116.       30.            BARNES    69 HBC  +  LAM.PI -3.9GEV/C 10/69*
W           120.       30.            BARNES    69 HBC  +  LAM.PI -5 GEV/C  10/69*
W          . . . . . . . . .
W    AVG    63.7       19.9    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.4)
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------   44 Y*1(1670) BRANCHING RATIOS   PROD. EXP.  -----------

R1        Y*1(1670) INTO (KBAR N)/(SIGMA PI) PROD. EXP.(P1)/(P3)
R1      0   (0.19)       OR LESS      ALVAREZ   63 HBC  + K-P AT 1.15 BEV/C
R1          (0.5)+- .25 OR MORE       SMITH     63 HBC  0-
R1          (0.6)        OR LESS      LONDON    66 HBC  + K-P AT 2.25 BEV/C  7/66
R1          (0.025)                   BUGG      68 CNTR 0 ASSUMING J=3/2    11/66
R1      0   (0.24)   OR  LESS         PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68
R1          (0.26)   OR LESS          BARNES    69 HBC  +  K-P 3.9-5 GEV/C  10/69*

R2        Y*1(1670) INTO (LAMB.PI)/(SIG PI) PROD. EXP.  (P2)/(P3)
R2     130   (1.20)                   ALVAREZ   63 HBC  + K-P AT 1.15 BEV/C
R2           (1.2)                    SMITH     63 HBC  0-
R2            0.15       0.07         HUWE      64 HBC  +
R2           (0.6)       OR LESS      LONDON    66 HBC  + K-P AT 2.25 BEV/C  7/66
R2      33    0.11       0.06         BUTTON-S  68 HBC  +  K-P AT 1.7 GEV/C 10/69*
R2  P    0   (0.)                     PRIMER    68 HBC  +  K-P 3.9-5 GEV/C  10/69*
R2  P   PRIMER 68 ASSUMED THIS DECAY TO BE ALL Y*1(1690)- SEE BARNES 69 FOR
R2  P   NEW INTERPRETATION OF DATA.(3 TIMES MORE DATA) -
R2            0.45       0.15         BARNES    69 HBC  +  K-P 3.9-5 GEV/C  10/69*
R2          . . . . . . . . .
R2  AVG       0.154      0.065   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.5)
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R3            Y*1(1670) INTO (LAMB. PI PI)/(SIG PI) PROD.  (P4)/(P3)
R3      90   (0.56)                    ALVAREZ   63 HBC  + K-P AT 1.15 BEV/C
R3           (0.17)                    SMITH     63 HBC  0-
R3           (0.6)        OR LESS      LONDON    66 HBC  + K-P AT 2.25 BEV/C  7/66

R4            Y*1(1670) INTO (SIGMA PI PI)/(SIG PI) PROD.  (P5)/(P3)
R4     180   (0.56)                    ALVAREZ   63 HBC  + K-P AT 1.15 B5V/C

R5            Y*1(1670) INTO (Y*0(1405) PI)/(SIG PI) PROD. (P7)/(P3)
R5      50     3.        1.6           LONDON    66 HBC  + K-P AT 2.25 BEV/C  7/66
R5  P   17   (0.58)    (0.20)          PRIMER    68 HBC  +  K-P 4.6-5. GEV/C  7/68

R6            Y*1(1670) INTO (SIGMA PI)/(SIGMA PI PI)        (P3)/(P5)
R6             (.4)  OR LESS           BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67
R6             0.30      0.15          LONDON    66 HBC  + K-P AT 2.25 BEV/3  7/66
R6  A         BETWEEN 2.5 AND 0.24     EBERHARD  69 HBC     K-P AT 2.6 GEV/C  9/69*
    A         DEPENDING ON THE PRODUCTION ANGLE

R7            Y*1(1670) INTO (Y*0(1405) PI)/(SIGMA PI PI)   (P7)/(P5)
R7             0.90      0.10      0.16  EBERHARD  65      + K-P AT 2.45 BEV/C  7/66

R8            Y*1(1670) INTO (Y*0(1405) PI)/(Y*1(1385) PI)  (P7)/(P6)
R8            (0.8)        CR MORE     EBERHARD  65      + K-P AT 2.45 BEV/C  7/66

R9        Y*1(1670) IN  (LAMBDA PI PI)/(SIGMA PI PI)       (P4)/(P5)
R9             0.35      0.2           BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67

R10       Y*1(1670) INTO (LAMBDA PI)/(SIGMA PI PI)          (P2)/(P5)
R10            (.2)  OR LESS           BIRMINGHA 66 HBC  +  K-P AT 3.5 GEV/C 11/67

R11           Y*1(1670) INTO (Y*1(1385) PI)/(SIG PI) PRO.  (P6)/(P3)
R11            0.4       0.1           BARNES    69 HBC  +  K-P 3.9-5 GEV/C  10/69*

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                     44 QUANTUM NUMBER DETERMINATION

Q1                     JP=3/2+                 LEVEQUE   65 HBC     INTO Y*(1405)+PI 11/68
Q2                     JP=3/2-                 SCHLEIN   66 DBC   0 INTO LAMBDA PI   11/68
Q3                     JP=3/2-                 EBERHARD  67 HBC  +  INTO Y*(1405) PI 11/68
Q4       400           JP=3/2-                 BUTTON-SH 68 HBC  +- INTO SIGZERO+PI  11/68

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                          REFERENCES -- Y*1(1660)    PRODUC. EXPERIMENTS

ALEXANDE 62 CERN CONF 320     ALEXANDER,JACOBS,KALBFLEISCH,MILLER,+ (LRL) I
ALVAREZ  63 PRL 10 184        +ALSTON,FERRO-LUZZI,HUWE, +              (LRL) I
SMITH    63 ATHENS CONF 67    G A SMITH                                (LRL)
HUWE     64 PR 180 1824(1969) D O HUWE                                 (LRL)
EBERHARD 65 PRL 14 466        +SHIVELY,ROSS,SIEGAL,FICENEC, +    (LRL,ILL) I

BIRMINGH 66 PR  152  1148     BIRMINGHAM,GLASGOW,I.C.Y OXFORD,RUTHERFORD
LONDON   66 PR 143 1034       +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+  (BNL,SYCR) IJ
BUGG     68 PR 168 1466       +GILMORE,KNIGHT,DAVIES+    (BIRMI,CAMB,RUTH)I
BUTTON-S 68 PRL 21 1123       J BUTTON SHAFER               (UNIV.MAS+LRL) JP
PRIMER   68 PRL 20 610        +GOLDBERG,JAEGER,BARNES,DORNAN +  (SYR,BNL)
BARNES   69 BNL 13823         BARNES,CHUNG,EISNER,FLAMINIO +     (BNL+SYR)
EBERHARD 69 PRL 22 200        +FRIEDMAN,PRIPSTEIN,ROSS                 (LRL)

                  REFERENCE FOR QUANTUM NUMBERS

T-ZADEH  63 PRL 11 470        TAHER-ZADEH,PROWSE,SCHLEIN,SLATER,+  (UCLA) JP
      --  SEE NOTE FOLLOWING SCHLEIN 66.
LEVEQUE  65 PL 18 69            +     (SACLAY,EP,GLASGOW,IMPCOL,OXF,RTHFD) JP
LEE      66 PRL 17 45         Y Y LEE, D D REEDER, R W HARTUNG      (WISC) JP
SCHLEIN  66 UCLA-1016         P E SCHLEIN, T G TRIPPE               (UCLA) JP
      --  REANALYZES DATA OF TAHER-ZADEH 63 AND BASTIEN 63 AND ALL PUBLISHED
          LAMBDA PI CROSS SECTION DATA IN THE LIGHT OF THE NOW KNOWN
          Y*1(1765) AND REVERSES THE MODEL-DEPENDENT CONCLUSION OF TAHER-
          ZADEH ON THE PREFERRED JP ASSIGNMENT (FROM 3/2+ TO 3/2-).

                  PAPERS NOT REFERRED TO IN DATA CARDS

EBERHARD 67 PR 163 1446       +PRIPSTEIN,SHIVELY,KRUSE,SWANSON  (LRL,ILL)IJP

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                    END Y*1(1660) PRODUCTION EXPERIMENTS

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Σ(1690)

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58  Y*1(1690, JP=     ) I=1

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

--> SEE NOTE PRECEDING Y*1(1660) LISTINGS, SEEN IN PRO.
    EXPERIMENTS ONLY

----------------   58  Y*1(1690) MASS (MEV)   --------------------------

M         30(1715.0)   (12.0)          COLLEY    67 HBC  +  K-P 6 GEV/C       8/67
M    P    60(1694.0)   (24.0)          PRIMER    68 HBC  +  K-P 4.6-5 GEV/C   7/68
M    P     SEE Y*1(1670) LISTING- BARNES 69 WITH 3 TIMES THE DATA OF PRIMER68
M    P     SHOW THAT THEY HAVE NO EVIDENCE FOR Y*1(1690).
M     N     (1700.0)    (6.0)          SIMS      68 HBC  -  K-N TO LAM PI PI 11/68
M     N    THIS ANALYSIS, WHICH IS DIFFICULT AND REQUIRES SEVERAL ASSUMPTIONS
M        AND SHOWS NO UNAMBIGUOUS Y*1(1690) SIGNAL, SUGGESTS JP=5/2+.  SUCH A
M        Y* WOULD LEAD ALL PREVIOUSLY KNOWN Y* TRAJECTORIES.
M          (1700.0)    (20.0)          MOTT      69 HBC  +  K-P 5.5 GEV/C     9/69*
M         46(1682.0)    (2.0)          BLUMENFEL 69 HBC  +  K0 LONG + PROTON  9/69*

----------------   58  Y*1(1690) WIDTH (MEV)   -------------------------

W         30 (100.0)   (35.0)          COLLEY    67 HBC  +                     8/67
W         60 (105.0)   (35.0)          PRIMER    68 HBC  +                     7/68
W     N       (62.0)   (14.0)          SIMS      68 HBC  -  SEE NOTE N ABOVE 11/68
W            (130.0)   (25.0)          MOTT      69 HBC  +                     9/69*
W         46  (25.0)   (10.0)          BLUMENFEL 69 HBC  +                     9/69*
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED

----------------   58  Y*1(1690) PARTIAL DECAY MODES   -----------------

                                                           DECAY MASSES
P1          Y*1(1690) INTO KBAR N                          497+ 939
P2          Y*1(1690) INTO LAMBDA PI                      1115+ 139
P3          Y*1(1690) INTO SIGMA PI                       1197+ 139
P4          Y*1(1690) INTO Y*1(1385) PI                   1385+ 139
P5          Y*1(1690) INTO LAMBDA PI PI (INCLUDING P4)    1115+ 139+ 139
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Data in parentheses have not been included in our averages.

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----------------   58  Y*1(1690) BRANCHING RATIOS   --------------------

R1     Y*1(1690) INTO (KBAR N)/(LAMBDA PI)                  (P1)/(P2)
R1     18      0.4       0.25            COLLEY    67 HBC  +  6/30 EVENTS      8/67
R1           (0.2)OR LESS                MOTT      69 HBC  +                   9/69*

R2     Y*1(1690) INTO (SIGMA PI)/(LAMBDA PI)                (P3)/(P2)
R2             0.3       0.3             COLLEY    67 HBC  +  4/30 EVENTS      8/67
R2           (0.4)OR LESS (90 PC CL)     MOTT      69 HBC  +                   9/69*

R3     Y*1(1690) INTO (Y*1(1385) PI)/(LAMBDA PI)            (P4)/(P2)
R3           (0.5)OR LESS                MOTT      69 HBC  +                   9/69*

R4     Y*1(1690) INTO (LAMBDA PI PI)/(LAMBDA PI)            (P5)/(P2)
R4             0.5       0.25            COLLEY    67 HBC  +  15/30 EVENTS     8/67
R4             2.0       0.6             BLUMENFEL 69 HBC  +  31/15 EVENTS     9/69*
R4           . . . . . . . . . .
R4  AVG        0.72      0.53   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

R5     Y*1(1690) INTO (Y*1(1385) PI)/(LAMBDA PI PI)         (P4)/(P5)
R5           SMALL                       COLLEY    67 HBC  +                   8/67
R5           LARGE                       SIMS      68 HBC  -                  11/68

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REFERENCES -- Y*1(1690)


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COLLEY   67 PL 24B 489          (BRMGHM,GLASG,IMPCOL,MUNICH,OXFORD,RTHRFRD) I
DERRICK  67 PRL 18 266          +FIELDS, LOKEN, AMMAR, (OARGONNE,NORTHWEST) I
   --  DERRICK 67 IS REPLACED BY MOTT 69.
PRIMER   68 PRL 20 610          +GOLDBERG, JAEGER, BARNES, + (SYRACUSE,BNL) I
SIMS     68 PRL 21 1413         +ALBRIGHT, +         (FLOR ST,TUFTS,BRANDEIS) I

ARMENTER 69 LUND CONF PAPER     ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)
BLUMENFE 69 PL 29B 58           B J BLUMENFELD, G R KALBFLEISCH        (BNL) I
MOTT     69 PR 177 1966         +AMMAR, DAVIS, KROPAC, +(NORTHWEST,ARGONNE) I
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PAPERS NOT REFERRED TO IN DATA CARDS

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ARMENTER 68 NP B8 183           ARMENTEROS, BAILLON, + (CERN,HEICEL,SACLAY)
BARNES   69 BNL 13823           BARNES,CHUNG,EISNER,FLAMINIO +    (BNL+SYR)
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Σ(1750)

57 Y*1(1750, JP=1/2-) I=1 **S_{11}**

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

THERE IS NOW EVIDENCE IN THREE CHANNELS FOR AN S11 RESONANCE NEAR THIS ENERGY. INTERPRETATION OF THE SIGMA ETA THRESHOLD BUMP ON ITS OWN MERITS IS NOT CONCLUSIVE (CLINE 67) -- MORE DATA ARE NEEDED. BUT BY ANALOGY WITH THE SIMILAR N ETA AND LAMBDA ETA THRESHOLD EFFECTS, WHICH ARE ALMOST CERTAINLY RESONANCES, IT SEEMS VERY LIKELY THAT THIS TOO IS A RESONANCE. SEE THE RAPPORTEUR TALKS OF FERRO LUZZI 66 AND MEYER 67 FOR DISCUSSIONS.

IN THE ENERGY-INDEPENDENT PARTIAL WAVE ANALYSIS OF K- N TO LAMBDA PI, THE S11 AMPLITUDE APPEARS TO RESONATE (ARMENTEROS 69). IN 1968 IT APPEARED TO RESONATE NEAR 1650 MEV (ARMENTEROS 68), AND WAS LISTED HEREIN AS A SEPARATE STATE. NOW IT HAS MOVED CLOSE ENOUGH TO THE OTHER EFFECTS TO BE TENTATIVELY LISTED WITH THEM, BUT THE SIZE OF THE CHANGE IN THE MASS SHOULD BE A HEALTHY WARNING THAT THE PARAMETERS GIVEN FOR RESONANCES IN LOWER PARTIAL WAVES FROM SUCH ANALYSES ARE SUBJECT TO LARGE CHANGE.

THERE IS WEAKER EVIDENCE FOR THIS RESONANCE IN AN ENERGY-DEPENDENT PARTIAL-WAVE ANALYSIS OF ELASTIC AND CHARGE-EXCHANGE SCATTERING (CONFORTO 69). THE ERRORS GIVEN FOR THIS SHOULD NOT BE TAKEN SERIOUSLY. THEY ARE STATISTICAL ONLY, AND DONT REFLECT THE LARGE SYSTEMATIC ERRORS THAT CAN RESULT FROM THE RESTRICTIVE PARAMETERIZATION FORCED ON THE PARTIAL WAVES.

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----------------   57  Y*1(1750) MASS (MEV)   --------------------------

M         NEAR SIGMA ETA THRESHOLD   CLINE     67 DBC  -  K-N TO SIGMA ETA  9/66
M         ABOUT 1750.0               MEYER     67 RVUE                      9/69*
M        (1730.0)                    ARMENTERO 69 HDBC 0- K-N TO LAM+PI EI  9/69*
M        (1764.0)    (3.0)           CONFORTO  69 HBC  0  ELASTIC, CH EXCH  9/69*

----------------   57  Y*1(1750) WIDTH (MEV)   -------------------------

W         ABOUT 50                   MEYER     67 RVUE                      9/69*
W         ABOUT 60 TO 100            ARMENTERO 69 HDBC 0-                   9/69*
W         (80.0)     (4.0)           CONFORTO  69 HBC  0                    9/69*

----------------   57  Y*1(1750) PARTIAL DECAY MODES   -----------------

                                                       DECAY MASSES
P1        Y*1(1750) INTO KBAR N                          497+ 939
P2        Y*1(1750) INTO SIGMA ETA                      1197+ 548
P3        Y*1(1750) INTO LAMBDA PI                      1115+ 134
P4        Y*1(1750) INTO SIGMA PI                       1197+ 139

----------------   57  Y*1(1750) BRANCHING RATIOS   --------------------

R1     Y*1(1750) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1            0.13      0.05         CONFORTO  69 HBC  0  S11 AMPLITUDE     9/69*

R2     Y*1(1750) INTO (KBAR N)*(SIGMA ETA)/TOTAL**2     (P1*P2)/TOTAL**2
R2          SEEN                     CLINE     69 DBC  -  THRESHOLD BUMP    9/69*

R3     Y*1(1750) INTO (KBAR N)*(LAMBDA PI)/TOTAL**2     (P1*P3)/TOTAL**2
R3        ABOUT 0.0225 TO 0.040      ARMENTERO 69 HDBC 0- S11 AMPLITUDE     9/69*

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REFERENCES -- Y*1(1750)


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FERRO-LU 66 BERKELEY CONF 183 M FERRO LUZZI  (RAPPORTEUR)           (CERN)
CLINE    67 PL 25B 41         CLINE, OLSSON                    (WISCONSIN)IJP
MEYER    67 HEIDELBERG C 117  J MEYER  (RAPPORTEUR)               (SACLAY)IJP
ARMENTER 68 NP B8 183         ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENTER 69 LUND CONF PAPER   ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
CONFORTO 69 LUND CONF PAPER   + HARMSEN, LASINSKI, +     (CHICAGO,HEIDEL)IJP
   --  ARMENTEROS 69 AND CONFORTO 69 NUMBERS ARE QUOTED IN LEVI SETTI 69.
LEVISETT 69 LUND CONF         R LEVI SETTI  (RAPPORTEUR)         (CHICAGO)IJP
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Σ(1765)

45 Y*1(1765, JP=5/2-) I=1 **D_{15}**

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

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----------------   45  Y*1(1765) MASS (MEV)   --------------------------

M          1765.0     10.0          GALTIERI  63 DBC  0  K-D 1.51 BEV/C
M          1755.0     10.0          ARMENTER  65 HBC  0  K-P TO Y*1520 PI   7/66
M          1760.0     10.0          BELL 1    66 DBC  -  K-N TO Y*1520 PI   7/66
M          1746.0      8.0          FENSTER   66 HBC  0  K-P TO Y*1520 PI   9/66
M          1768.0      4.0          BUGG      68 CNTR    K-P, D TOTAL      11/66
M          1775.0      7.0          SMART     68 RVUE 0- K-N TO LAMBDA PI   7/68
M   N     (1768.0)    (2.0)         ARMENT-1  68 HBC  0  ELASTIC, CH EXCH  11/68
M   N     (1765.0)    (3.0)         CONFORTO  68 HBC  0  ELASTIC, CH EXCH  11/68
M   N   THESE TWO ANALYZE ESSENTIALLY THE SAME DATA IN DIFFERENT WAYS.
M         . . . . . . . . . .
M   AVG    1764.6      3.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)
    N   STATISTICAL ERROR QUOTED, SYSTEMATIC ERROR CAN BE LARGE. NOT
    N   AVERAGED.

----------------   45  Y*1(1765) WIDTH (MEV)   -------------------------

W            60.0     10.0          GALTIERI  63 DBC  0
W            70.0     20.0          BELL 2    66 DBC  -                     7/66
W            70.0     20.0          FENSTER   66 HBC  0                     9/66
W           110.0      7.0          BUGG      68 CNTR    K-P,D TOTAL        7/68
W           146.0      9.0          SMART     68 RVUE 0-                    7/68
W   N      (128.0)    (8.0)         ARMENT-1  68 HBC  0  SEE NOTE N ABOVE 11/68
W   N      (112.0)    (5.0)         CONFORTO  68 HBC  0  SEE NOTE N ABOVE 11/68
W         . . . . . . . . . .
W   AVG     104.6     15.8     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 3.5)
                       (SEE IDEOGRAM BELOW )
              SEE THE NOTES ACCOMPANYING THE MASSES QUOTED
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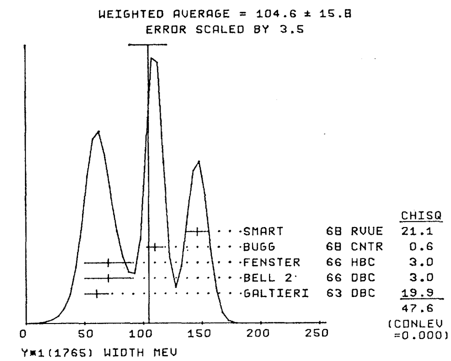


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----------------   45  Y*1(1765) PARTIAL DECAY MODES   -----------------

                                                       DECAY MASSES
P1        Y*1(1765) INTO KBAR N                          497+ 939
P2        Y*1(1765) INTO LAMBDA PI                      1115+ 134
P3        Y*1(1765) INTO Y*0(1520) PI                   1520+ 139
P4        Y*1(1765) INTO Y*1(1385) PI                   1385+ 139
P5        Y*1(1765) INTO SIGMA PI                       1197+ 139
P6        Y*1(1765) INTO SIGMA ETA                      1197+ 548
P7        Y*1(1765) INTO SIGMA PI PI                    1197+ 139+ 139

----------------   45  Y*1(1765) BRANCHING RATIOS   --------------------

R1     Y*1(1765) INTO (KBAR N)/TOTAL                    (P1)/TOTAL
R1           (0.6)                  GALTIERI  63 HBC  0  K-P RVUE
R1            0.53     0.09         UHLIG     67 HBC  0                     9/66
R1           (0.37)                 BUGG      68 CNTR                      11/66
R1  N         0.45     0.01         ARMENT-1  68 HBC  0  SEE NOTE N ABOVE 11/68
R1  N         0.44      .03         CONFORTO  68 HBC  0  SEE NOTE N ABOVE 11/68
R1          . . . . . . . . . .
R1  AVG       0.4499   0.0094  AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)
R1  FIT       0.4531   0.0091   VALUE FROM CONSTRAINED FIT

R2     Y*1(1765) INTO (LAMBDA PI)*(KBAR N)/TOTAL**2     (P2*P1)/TOTAL**2
R2            0.07     0.01         SMART     68 DBC  -                     7/68
R2          . . . . . . . . . .
R2  FIT       0.0689   0.0073   VALUE FROM CONSTRAINED FIT

R3     Y*1(1765) INTO (Y*0(1520) PI)*(KBAR N)/TOTAL**2  (P3*P1)/TOTAL**2
R3            0.075    0.015        ARMENTERO 65 HBC    OHYPERONS FIN.ST.  9/66
R3            0.12     0.03         FENSTER   66 HBC    OKBAR N  FIN. ST.  9/66
R3          . . . . . . . . . .
R3  AVG       0.084    0.018   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)
R3  FIT       0.0673   0.0096   VALUE FROM CONSTRAINED FIT

R4     Y*1(1765) INTO (Y*1(1385) PI)*(KBAR N)/TOTAL**2  (P4*P1)/TOTAL**2
R4            0.057    0.013        ARMENTE2  67 HBC  -  K-P TO LAM PI PI  8/67
R4            0.105    0.040        SIMS      68 DBC  -  K-N TO LAM.PI PI 11/68
R4          . . . . . . . . . .
R4  AVG       0.062    0.014   AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)
R4  FIT       0.058    0.010    VALUE FROM CONSTRAINED FIT

R5     Y*1(1765) INTO (SIGMA PI)*(KBAR N)/TOTAL **2     (P5*P1)/TOTAL**2
R5            0.005    0.003        ARMENTERO 67 HBC  0 K-P TO SIGMA PI    8/67
R5          . . . . . . . . . .
R5  FIT       0.0050   0.0030   VALUE FROM CONSTRAINED FIT

R6     Y*1(1765) INTO (LAMBDA PI)/(KBAR N)              (P2)/(P1)
R6            0.33     0.05         UHLIG     67 HBC  0 K-P,.9 GEV/C       9/66
R6          . . . . . . . . . .
R6  FIT       0.336    0.036    VALUE FROM CONSTRAINED FIT

R7     Y*1(1765) INTO (Y*0(1520)/(KBAR N)               (P3)/(P1)
R7            0.28     0.05         UHLIG     67 HBC  0 K-P,.9 GEV/C       9/66
R7          . . . . . . . . . .
R7  FIT       0.328    0.045    VALUE FROM CONSTRAINED FIT
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Data in parentheses have not been included in our averages.

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R8     Y*1(1765) INTO (Y*1(1385)/(KBAR N)                    (P4)/(P1)
R8             0.25      0.09            UHLIG     67 HBC   0 K-P,.9 GEV/C      9/66
R8           . . . . . . . . . .
R8   FIT       0.285     0.051    VALUE FROM CONSTRAINED FIT

R9      Y*1(1765) INTO (SIGMA PI PI)/TOTAL                    (P7)/TOTAL
R9    P        (0.12)                    ARMENT-2  68 HDBC 0- K-N TO SIG PI PI 11/68
R9    P    FOR ABOUT 3/4 OF THIS, THE SIGMA PI SYSTEM HAS I=0 AND IS ALMOST
R9    P ENTIRELY Y*0(1520).  FOR THE OTHER 1/4, THE SIGMA PI HAS I=1.  THIS
R9    P IS ABOUT WHAT IS EXPECTED FROM THE KNOWN RATE Y*1(1765) TO Y*1(1385)
R9    P PI, AS SEEN IN LAMBDA PI PI.
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Fitted Partial Decay Mode Branching Fractions

Diagonal elements are $P_i \pm \delta P_i$; $\delta P_i = \sqrt{\langle \delta P_i \delta P_i \rangle}$. Off-diagonal elements are correlation coefficients $= \langle \delta P_i \delta P_j \rangle / (\delta P_i \cdot \delta P_j)$.

	P 1	P 2	P 3	P 4	P 5	P 6
P 1	.453+-.009					
P 2	-.001	.152+-.016				
P 3	.C94	-.000	.148+-.021			
P 4	-.035	.000	-.003	.129+-.023		
P 5	-.034	.000	-.003	.001	.011+-.007	
P 6	-.277	-.440	-.567	-.623	-.175	.106+-.037

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                          REFERENCES -- Y*1(1765)
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GALTIERI 63 PL 6 296           A BARBARO-GALTIERI,A HUSSAIN,RD TRIPP (LRL)IJ
ARMENTER 65 PL 19 338          ARMENTEROS, +       (CERN,HEIDELBERG,SACLAY)IJP
BELL 1   66 PRL 16 203         R B BELL, R W BIRGE, Y-L PAN, R T PU   (LRL)IJP
BELL 2   66 UCRL-16936 THESIS  R B BELL                                (LRL)IJP
FENSTER  66 PRL 17 841         +GELFAND,HARMSEN,L-SETTI,+  (CHI,ARG(CERN))IJP
ARMENTER 67 PL 248 198         ARMENTEPOS,FERRO-LUZZI+  (CERN,HEID,SACLAY)IP
ARMENTE2 67 ZEIT.PHYS.202,486  ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
UHLIG    67 PR 155 1448        +CHARLTON,CONCON,GLASSER,YODH,+  (MD,USNRL)

ARMENT-1 68 NP B8 195          ARMENTEROS, BAILLON, + (CERN,HEIDEL,SACLAY)IJP
ARMENT-2 68 NP B8 216          ARMFNTEROS, BAILLON, + (CERN,HEIDEL,SACLAY) I
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+    (BIRMI,CAMB,RUTH)I
CONFORTO 68 NP B8 265          +HARMSEN, LASINSKI, +      (CHICAGO,HEIDEL)IJP
SIMS     68 PRL 21 1413        SIMS,ALBRIGHT,BARTLEY,MEER+ (FLO+TAFTS+BRA)
SMART    68 PR 169 1330        W M SMART                               (LRL)IJP
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Σ(1880) P''11

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67  Y*1(1880, JP=1/2+) I=1

SEE THE MINI-REVUE AT THE START OF THE Y* LISTINGS.

PARTIAL-WAVE ANALYSIS OF K- N TO LAMBDA PI SUGGESTS
SUCH A RESONANCE, BUT FURTHER EVIDENCE IS REQUIRED.

----------------  67  Y*1(1880) MASS (MEV)  --------------------------

M         1882.0    40.0            SMART      68 RVUE 0- K-N TO LAMBDA PI  7/68

----------------  67  Y*1(1880) WIDTH (MEV)  -------------------------

W          222.0   150.0            SMART      68 RVUE 0-                   7/68

----------------  67  Y*1(1880) PARTIAL DECAY MODES  -----------------

                                                         DECAY MASSES
P1          Y*1(1880) INTO KBAR N                         497+ 939
P2          Y*1(1880) INTO LAMBDA PI                     1115+ 134

----------------  67  Y*1(1880) BRANCHING RATIOS  --------------------

R1      Y*1(1880) INTO (KBAR N)*(LAMBDA PI)/TOTAL**2      (P1*P2)/TCTAL**2
R1             0.012     0.007      SMART      68 RVUE 0-                   7/68

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                          REFERENCES -- Y*1(1880)
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SMART    68 PR 169 1330        W M SMART                               (LRL)IJP
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Σ(1915) F15

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46  Y*1(1915, JP=5/2+) I=1

SEE THE MINI-REVIEW AT START OF Y* LISTING

 SOME RESERVATION SHOULD BE HELD AGAINST COMPLETE
 ACCEPTANCE OF THE INTERPRETATION OF THIS EFFECT

 FORMATION EXPERIMENTS PRESENT WEAK EVIDENCE FCR IT -
 PRODUCTION EXPERIMENTS SEE A STATE AT THIS MASS, OF
 UNKNOWN QUANTUM NUMBERS- SEE LISTING OF PRODUCTION
 EXPERIMENTS BELOW-

----------------  46  Y*1(1915) MASS (MEV)  --------------------------

M          1902.0    11.0           SMART      68 RVUE  -0 K-N TO LAM.PI    7/68

----------------  46  Y*1(1915) WIDTH (MEV)  -------------------------

W   A     (50.0)   (20.0)           ARMENTER1 67 HBC    OK-P EL. +CH.EXC. 11/67
W   A LACK OF DATA PREVENTS AUTHORS FROM DETERMINING UNAMBIG  THIS AMPLITU. 11/67
W           52.0    25.0            SMART      68 RVUE  -0 K-N TO LAM.PI    7/68

----------------  46  Y*1(1915) PARTIAL DECAY MODES  -----------------

                                                         DECAY MASSES
P1          Y*1(1915) INTO KBAR N                         497+ 939
P2          Y*1(1915) INTO LAMBDA PI                     1115+ 139
P3          Y*1(1915) INTO SIGMA PI                      1197+ 139

----------------  46  Y*1(1915) BRANCHING RATIOS  --------------------

R1          Y*1(1915) INTO (KBAR N)/TOTAL                  (P1)/TOTAL
R1  A        (0.12)    (.01)        ARMENTER1 67 HBC  0  K-P EL. +CH.EXC. 11/67
R1  A LACK OF DATA PREVENTS AUTHORS FROM DETERMINING UNAMBIG  THIS AMPLITU. 11/67
R1  C        (0.10)    (0.01)       CONFORTC  68 HBC  0  K-P ELASTIC      11/68
R1  C    FIT TO K-P ELAS. DIFFER. CROSS SECTIONS (PART OF DATA INCLUDED IN
R1  C    ARMENTEROS 68 WHICH FIT LEGEN. POLYN. COEFFICENTS)

R2      Y*1(1915) INTO (LAMBDA PI)*(KBAR N)/TOTAL**2      (P1*P2)/TOTAL**2
R2  A        (0.006)                ARMENTER1 67 HBC    OK-P TO LAM.PI    11/67
R2  A LACK OF DATA PREVENTS AUTHORS FROM DETERMINING UNAMBIG  THIS AMPLITU. 11/67
R2            0.006     0.003       SMART      68 RVUE  -0 K-N TO LAM.PI    7/68

R3      Y*1(1915) INTO (SIGMA PI)*(KBAR N)/TOTAL**2       (P1*P3)/TOTAL**2
R3  A        (0.00)    (0.01)       ARMENTERO 67 HBC     K-P TO SIG+-PI-+ 11/67
R3  A LACK OF DATA PREVENTS AUTHORS FROM DETERMINING UNAMBIG  THIS AMPLITU. 11/67
R3           (0.0004)OR LESS        GALTIERI  69 HBC     K-P TO SIG+-PI-+ 10/69*

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                          REFERENCES -- Y*1(1915)
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ARMENTER 67 PL 248 198         ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)
ARMENTE1 67 NP B3 592          ARMENTEROS,FERRO-LUZZI+  (CERN,HEID,SACLAY)

CONFORTO 68 EFI 68-62 NP TBP. B.CONFORTO,HARMSEN+BURKHARDT+  (EFINS+HEID)
SMART    68 PR 169 1330        W M SMART                               (LRL)
GALTIERI 69 LUND PAPER 90      A BARBARO GALTIERI                      (LRL)

                     PAPERS NOT REFERRED TO IN DATA CARDS

SMART    66 PRL 17 556         W M SMART,A KERNAN,G E KALMUS,R P ELY (LRL)IJP
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1900 MEV REGION – PRODUCTION AND σ_{TOTAL} EXPERIMENTS

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                    29  Y*(1900)       PRODUCTION EXPERIMENTS

                     THE QUANTUM NUMBERS OF THE EFFECT SEEN IN THESE EXPE-
                     RIMENTS ARE NOT KNOWN -

----------------  29 Y*(1900) MASS (MEV)    PROD. EXP. ----------------

M          (1942.0)    (9.0)            BOCK      65 HBC      PBAR P 5.7 BEV/C
M           1915.0     20.0             COOL      66 CNTR 0-  K-P, D TOTAL     7/66
M           1905.0      5.0             BUGG      68 CNTR     K-P, D TOTAL    11/66
M        42 1940.      20.              BARNES    69 HBC    + K-P 3.9,5. GEV/C 10/69*
M            . . . . . . . . . .
M   AVG     1907.5      5.8       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.2)

----------------  29 Y*(1900) WIDTH (MEV)    PROD. EXP. ----------------

W           (36.0)    (20.0)   (36.0)  BOCK      65 HBC
W           (65.0)                     COOL      66 CNTR 0-                    7/66
W            60.0      10.0            BUGG      68 CNTR                      11/66
W        42  100.      30.             BARNES    69 HBC    + K-P 3.9,5. GEV/C 10/69*
W            . . . . . . . . . .
W   AVG      64.0      12.0       AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.3)

----------------  29 Y*(1900) BRANCHING RATIOS    PROD. EXP. ------------

R1          Y*(1900) INTO (KBAR N)/TOTAL           PRODUC. EXP.
R1      RATIOS CALCULATED ASSUMING J=5/2
R1            (0.103)                   COOL      66 CNTR     ASSUMING J=5/2     7/66
R1            (0.09)                    KYCIA     67 CNTR     TOTAL CROSS-SEC.   8/67
R1            (0.06)                    BUGG      68 CNTR     ASSUMING J=5/2     6/68

R2          Y*(1900) INTO (KBAR N)/(SIGMA PI)      PRODUC. EXP.
R2             (.37)    OR  LESS        BARNES    69 HBC    +   1 STAN. DEV.    10/69*

R3      Y*1(1915)  INTO (LAMBDA PI)/TOTAL          PRODUC. EXP.
R3  P     50     SEEN                   PRIMER    68 HBC    + K-P 4.6-5. GEV/C  7/68
R3  P        SEE BARNES 69 BELOW - IT IS SAME EXPERIMENT WITH IMPROVED STATI. 10/69*

R4          Y*(1900) INTO (LAM+PI)/(SIGMA PI)      PRODUC. EXP.
R4             (.28)    OR  LESS        BARNES    69 HBC    +   1 STAN. DEV.    10/69*

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                        REFERENCES --Y*(1900)-- PROD. EXPERIMENTS
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BOCK     65 PL 17 166          +COOPER,FRENCH,KINSON, +        (CERN,SACLAY) I
COOL     66 PRL 16 1228        +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
KYCIA    67 PRIVATE COMM.      T F KYCIA                               (BNL) I
BUGG     68 PR 168 1466        +GILMORE,KNIGHT,DAVIES+    (BIRMI,CAMB,RUTH)I
PRIMER   68 PRL 20 610         +GOLDBERG,JAEGER,BARNES,DORNAN +  (SYR,BNL)
BARNES   69 PRL 22 479         +FLAMINIO,MONTANET,SAMIOS +       (BNL+SYRA)
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                    END PRODUCTION EXPERIMENTS
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Σ(2030) F17

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47  Y*1(2030, JP=7/2+) I=1

SEE THE MINI-REVIEW AT START OF Y* LISTING.

 WOHL 66, SMART 68, AND DAUM 68 FIND JP=7/2+.

PARTIAL WAVE ANALYSIS OF GALTIERI 69 IN SIGMA PI
CHANNEL REQUIRES TWO STATES AT SIMILAR MASS WITH
SAME J, OPPOSITE P.

----------------  47  Y*1(2030) MASS (MEV)  --------------------------

M          (2030.0)   (20.0)           WOHL      66 HBC  0  K-P TO LAM PIO     7/66
M           2032.0      6.0            SMART     68 RVUE    K-N TO LAM PI      6/68
M          (2020.)                     GALTIERI  69 HBC     SIGPI PAR.WAVE A 10/69*

----------------  47  Y*1(2030) WIDTH (MEV)  -------------------------

W          (170.0)                     WOHL      66 HBC  0                     7/66
W           160.0      16.0            SMART     68 RVUE    INCLUDES WOHL 66   6/68
W           (80.)                      GALTIERI  69 HBC     SIGPI PAR.WAVE A 10/69*

----------------  47  Y*1(2030) PARTIAL DECAY MODES  -----------------

                                                         DECAY MASSES
P1          Y*1(2030) INTO KBAR N                         497+ 939
P2          Y*1(2030) INTO LAMBDA PI                     1115+ 134
P3          Y*1(2030) INTO SIGMA PI                      1197+ 139
P4          Y*1(2030) INTO XI K                          1321+ 497

----------------  47  Y*1(2030) BRANCHING RATIOS  --------------------

R1          Y*1(2030) INTO (KBAR N)/TOTAL                  (P1)/TOTAL
R1           (0.25)                     WOHL      66 HBC  0  K-P CH EX         7/66
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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

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R2    Y*1(2030) INTO (LAMBDA PI)*(KBAR N)/TOTAL**2        (P2)*(P1)/TOTAL**2
R2         (0.040)                  WOHL      66 HBC    K-P TO LAM PIO    7/66
R2          0.045    0.004          SMART     68 RVUE   INCLUDES WOHL     6/68

R3       Y*1(2030) INTO (SIG PI)*(KBAR N)/TOTAL**2    (P2*P1)/TOTAL**2
R3          (.0041)                 GALTIERI  69 HBC    SIGPI PAR.WAVE A 10/69*

R4    Y*1(2030) INTO (XI K)*(KBAR N)/TOTAL**2             (P4)*(P1)/TOTAL**2
R4         (0.0025)  OR LESS        TRIPP     67 RVUE                     8/67
R4          (.0025)  OR LESS        BURGUN    68 HBC   O K-P TO XI-K (8) 10/69*

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                         REFERENCES -- Y*1(2030)

WOHL     66 PRL 17 107        C G WOHL, F T SOLMITZ, M L STEVENSON  (LRL)IJP
TRIPP    67 NP B3 10          + LEITH, +    (LRL,SLAC,CERN,HEIDEL,SACLAY)
BURGUN   68 NP B8 447         +MEYER,PAULT,TALLINI +       (SACL+CDF+RHEL)
DAUM     68 NP B7 19          +ERNE, LAGNAUX, SENS, STEUER, UDO    (CERN)JP
SMART    68 PR 169 1336       W M SMART                             (LRL)IJP
GALTIERI 69 LUND PAPER 90     A BARBARO GALTIERI                    (LRL)IJP

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Σ(2130) G_{17}

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                  26  Y*1(2130, JP=7/2- ) I=1

                  SEE THE MINI-REVIEW AT START OF Y* LISTING

----------------  26  Y*1(2130)  MASS  (MEV)  -------------------------

M        (2130.)                    GALTIERI  69 HBC    SIGPI PAR.WAVE A 10/69*

----------------  26  Y*1(2130)  WIDTH (MEV)  -------------------------

W         (135.)                    GALTIERI  69 HBC    SIGPI PAR.WAVE A 10/69*

----------------  26  Y*1(2130)  PARTIAL DECAY RATES  -----------------

                                                        DECAY MASSES
P1        Y*1(2130) INTO KBAR N                         497+ 939
P2        Y*1(2130) INTO SIGMA PI                      1197+ 139

----------------  26  Y*1(2130)  BRANCHING RATIOS     -----------------

R1        Y*1(2130) INTO (SIG PI)*(KBAR N)/TCTAL**2   (P2*P1)/TOTAL**2
R1           (.0225)                GALTIERI  69 HBC    SIGPI PAR.WAVE A 10/69*

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                         REFERENCES -- Y*1(2130)

GALTIERI 69 LUND PAPER 90     A BARBARO GALTIERI                    (LRL)IJP

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2100 MEV REGION – PRODUCTION AND σ_{TOTAL} EXPERIMENTS

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                  28  Y*1(2000)  PRODUC. EXPER.

                  THE BUMP SEEN AT THIS MASS IN TOTAL CROSS SECTION EXPE.
                  CONTAINS BOTH THE GO7 AND FO7 STATES ABOVE-

----------------  28  Y*1(2000)  MASS (MEV)   PROD. EXP. ---------------

M        (2022.0)  (20.0)           BLANPIED  65 CNTR O  GAMMA P TO K+ Y*
M         2026.0    19.0            KYCIA     67 CNTR    K-P, D TOTAL     8/67
M         2020.0     7.0            BUGG      68 CNTR    K-P, C TOTAL     6/68
M         . . . . . . . . . .
M   AVG   2020.7     6.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  28  Y*1(2000)  WIDTH (MEV)  PROD. EXP. ---------------

W        (120.0)   (20.0)           BLANPIED  65 CNTR O
W         120.0     10.0            KYCIA     67 CNTR                     8/67
W         130.0     10.0            BUGG      68 CNTR                     6/68
W         . . . . . . . . . .
W   AVG   125.0      7.1     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  28  Y*1(2000)  BRANCHING RATIOS  PROD. EXP. ----------

R1          0.105    0.005          KYCIA     67 CNTR                     8/67
R1         (0.131)                  BUGG      68 CNTR                     6/68

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                         REFERENCES --Y*1(2000)-- PROD. EXPERIMENTS

BLANPIED 65 PRL 14 741        +GREENBERG,HUGHES,KITCHING,LU,+ (YALE(CEA))
COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  SLIGHTLY REVISEC RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA    67 PRIVATE COMM.     T F KYCIA                            (BNL) I
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +    (RTHFD,BRMGHM,CVNDSH) I

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Σ(2250)

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                  48  Y*1(2250, JP=    ) I=1

                  SEE THE MINI-REVIEW AT START OF Y* LISTING

----------------  48  Y*1(2250) MASS (MEV)   ------------------------
M        (2245.0)                   BLANPIED  65 CNTR    GAMMA P TO K+ Y*
M        (2299.0)    (6.0)          BOCK      65 HBC     PBAR P 5.7 BEV/C
M         2252.0    10.0            KYCIA     67 CNTR    K-P, D TOTAL     8/67
M         2250.0     7.0            BUGG      68 CNTR    K-P, D TOTAL     6/68
M      42 2280.     20.             BARNES    69 HBC   + K-P 3.9,5. GEV/C 10/69*
M         . . . . . . . . . .
M   AVG   2252.9     5.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  48  Y*1(2250) WIDTH (MEV)   ------------------------

W         (150.0)                   BLANPIED  65 CNTR
W          (21.0)   (17.0)  (21.0)  BOCK      65 HBC
W          200.0    20.0            KYCIA     67 CNTR                     8/67
W          230.0    20.0            BUGG      68 CNTR                     6/68
W      42  120.     30.             BARNES    69 HBC   + K-P 3.9,5. GEV/C 10/69*
W         . . . . . . . . . .
W   AVG    197.7    27.6     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.2)

----------------  48  Y*1(2250) PARTIAL DFCAY MODES    ----------------

                                                         DECAY MASSES
P1        Y*1(2250) INTO KBAR N                          497+ 939
P2        Y*1(2250) INTO KBAR N PI                       497+ 939+ 139
P3        Y*1(2250) INTO  SIGMA PI                      1197+ 139
P4        Y*1(2250) INTO  LAMBDA PI                     1115+ 134

----------------  48  Y*1(2250) BRANCHING RATIOS    -------------------

R1        Y*1(2250) INTO.(KBAR N)/TOTAL                 (P1)/TOTAL
     J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(KBAR N)/TOTAL
R1          0.31     0.02           KYCIA     67 CNTR                     8/67
R1         (0.47)                   BUGG      68 CNTR                     6/68

R2        Y*1(2250) INTO (KBAP N)/(SIG PI)             (P1)/(P3)
R2          (.18)  OR LESS          BARNES    69 HBC    + 1 ST. DEVIAT.  10/69*

R3        Y*1(2250) INTO (LAMBDA PI)/(SIG PI)          (P4)/(P3)
R3          (.18)  OR LESS          BARNES    69 HBC    + 1 ST. DEVIAT.  10/69*

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                         PEFERENCES -- Y*1(2250)

BLANPIED 65 PRL 14 741        +GREENBERG,HUGHES,KITCHING, +    (YALE(CEA))
BOCK     65 PL 17 166         +COOPER,FRENCH,KINSON, +        (CERN,SACLAY)
COOL     66 PRL 16 1228       +GIACOMELLI,KYCIA,LEONTIC,LI,LUNDBY,+ (BNL) I
     --  SLIGHTLY REVISED RESULTS FROM KYCIA 67 REPLACE COOL 66 --
KYCIA    67 PRIVATE COMM.     T F KYCIA                            (BNL) I
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +    (RTHFD,BRMGHM,CVNDSH) I
BARNES   69 PRL 22 479        +FLAMINIO,MONTANET,SAMIOS +       (BNL+SYRA)

                    PAPER NOT REFERRED TO IN DATA CARDS.

DAUBER   66 PL 23 154         +SCHLEIN, SLATER, STORK, TICHO  (UCLA(LRL)) J
     --  SUGGESTS J=9/2 RESONANT BEHAVIOR IN SIGMA- PI+, BUT APPEARS
         INCONSISTENT WITH PARAMETERS OF COOL 66.

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Σ(2455)

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                  53  Y*1(2455, JP=    ) I=1

                  SEE THE MINI-REVIEW AT START OF Y* LISTING

                   ONE OF TWO NEW SMALL BUMPS IN THE I=1 TOTAL CROSS
                   SECTION (SEE THE Y*1(2595)). IT IS REASONABLE TO
                   INTERPRET THEM AS RESONANCES, THOUGH THAT IS NOT
    CERTAIN.  THERE IS ALSO LESSER EVIDENCE FOR NEW STRUCTURE IN THE I=0
    CROSS SECTION -- SEE ABRAMS 67.
                   THERE IS ALSO SOME SLIGHT EVIDENCE FOR Y* STATES IN
    THIS MASS REGION FROM THE REACTION GAMMA + P TO K+ + MISSING MASS --
    SEE GREENBERG 68.

----------------  53  Y*1(2455) MASS (MEV)    ------------------------

M         2455.0    10.0            ABRAMS    67 CNTR   K-P, D TOTAL    11/67
M         2455.0     7.0            BUGG      68 CNTR   K-P, D TOTAL     6/68
M         . . . . . . . . . .
M   AVG   2455.0     5.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  53  Y*1(2455) WIDTH (MEV)    -----------------------

W        (140.0)  APPROXIMATELY     ABRAMS    67 CNTR                    11/67
W         100.0     20.0            BUGG      68 CNTR                     6/68

----------------  53  Y*1(2455) PARTIAL DECAY MODES    ---------------

                                                         DECAY MASSES
P1        Y*1(2455) INTO KBAR N                          497+ 939

----------------  53  Y*1(2455) BRANCHING RATIOS    ------------------

R1        Y*1(2455) INTO (KBAR N)/TOTAL                 (P1)/TOTAL
     J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(KBAR N)/TOTAL
R1         (0.26)                   ABRAMS    67 CNTR                    11/67
R1         (0.3)                    BUGG      68 CNTR                     6/68

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                         REFERENCES -- Y*1(2455)

ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)
BUGG     68 PR 168 1466       +GILMORE,KNIGHT, +    (RTHFD,BRMGHM,CVNDSH) I
GREENBER 68 PRL 20 221        GREENBERG, HUGHES, LU, MINEHART, +   (YALE)

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Σ(2595)

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                  54  Y*1(2595, JP=    ) I=1

                  SEE NCTE UNDER THE Y*1(2455).

----------------  54  Y*1(2595) MASS (MEV)    ------------------------

M         2595.0    10.0            ABRAMS    67 CNTR   K-P, C TOTAL    11/67

----------------  54  Y*1(2595) WIDTH (MEV)    -----------------------

W        (140.0)  APPROXIMATELY     ABRAMS    67 CNTR                    11/67

----------------  54  Y*1(2595) PARTIAL DECAY MODES    ---------------

                                                         DECAY MASSES
P1        Y*1(2595) INTO KBAR N                          497+ 939

----------------  54  Y*1(2595) BRANCHING RATIOS    ------------------

R1        Y*1(2595) INTO (KBAR N)/TOTAL                 (P1)/TOTAL
     J IS NOT KNOWN.  FOLLOWING IS (J+1/2)*(KBAR N)/TOTAL
R1         (0.26)                   ABRAMS    67 CNTR                    11/67

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                         REFERENCES -- Y*1(2595)

ABRAMS   67 PRL 19 678        +COOL,GIACOMELLI,KYCIA,LEONTIC,LI, +  (BNL)

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See the illustrated key preceding the data card listings.

Data in parentheses have not been included in our averages.

Σ(3000)

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                 59  Y*1(3000, JP=     ) I=1

                 ENHANCEMENT IN LAMBDA PI AND KBAR N INVARIANT MASS
                 SPECTRA AND IN MISSING MASS OF NEUTRALS RECOILING
                 AGAINST KO.  EVIDENCE NOT CONCLUSIVE.  OMITTED FROM
                 TABLE.

----------------  59  Y*1(3000) MASS (MEV)   ---------------------------

M       (3000.0)                  EHRLICH   66 HBC  0  PI-P 7.91 BEV/C   9/66

----------------  59  Y*1(3000) PARTIAL DECAY MODES   -----------------

                                                            DECAY MASSES
P1          Y*1(3000) INTO KBAR N                          497+ 939
P2          Y*1(3000) INTO LAMBDA PI                      1115+ 139

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                      REFERENCES -- Y*1(3000)

EHRLICH  66 PR 152 1194    . R EHRLICH, W SELOVE, H YUTA     (PENN(BNL)) I

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Ξ^-

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                 22  XI -     (1321,JP=1/2 )  I=1/2
                 SEE LISTINGS OF STABLE PARTICLES

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Ξ^0

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                 23  XI 0     (1314, JP=1/2 )  I=1/2
                 SEE LISTINGS OF STABLE PARTICLES

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Ξ(1530) P_{13}

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                 49  XI*1/2(1530, JP=3/2+) I=1/2
                 THIS IS THE ONLY WELL-UNDERSTOOD XI*.

----------------  49  XI*1/2(1530) MASS (MEV)   -----------------------

M       (1529.0)   (5.0)         PJERRCU   62 HBC  0- K-P 1.8 BEV/C
M       (1532.0)   (2.0)         BADIER    64 HBC  0- K-P 3 BEV/C
M-       1535.7     3.2          LONDON    66 HBC  -  K-P 2.24 BEV/C    7/66
MO       1528.7     1.1          LONDON    66 HBC  0                    7/66

----------------  49  XI*(-)-XI*(0) MASS DIFFERENCE (MEV)   ------------

D           5.7     3.0          PJERRCU   65 HBC  0- K-P 1.8-1.95 B/C  7/66
D   R      (7.0)   (4.0)         LONDON    66 HBC  0-                   7/66
D   R    REDUNDANT WITH DATA IN MASS LISTING.
D           2.0     3.2          MERRILL   66 HBC  0- K-P 1.7-2.7 BE/C  7/66
D        . . . . . . . . . .
D   AVG     4.0     2.2     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  49  XI*1/2(1530) WIDTH (MEV)   ----------------------

W           7.0     2.0          SCHLEIN   63 HBC  0  K-P 1.8-1.95 B/C
W           8.5     3.5          LONDON    66 HBC  0                    7/66
W           7.0     7.0          BERGE     66 HBC  0  K-P 1.5-1.7 BE/C  7/66
W        . . . . . . . . . .
W   AVG     7.3     1.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

----------------  49  XI*1/2(1530) PARTIAL DECAY MODES   --------------

                                                            DECAY MASSES
P1          XI*1/2(1530) INTO XI PI                       1321+ 139

      OTHER STRONG DECAYS ARE FORBIDDEN BY ENERGY CONSERVATION.

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                      REFERENCES -- XI*1/2(1530)

PJERRCU  62 PRL 9 114         +PROWSE,SCHLEIN,SLATER,STORK,TICHO    (UCLA) I
SCHLEIN  63 PRL 11 167        +CARMONY,PJERROU,SLATER,STORK,TICHO   (UCLA)IJP
BADIER   64 DUBNA I 593       +DEMOULIN,GOLDBERG, +       (EP,SACLAY,AMSTR) I
PJERRCU  65 PRL 14 275        +SCHLEIN,SLATER,SMITH,STORK,TICHO     (UCLA)
LONDON   66 PR 143 1034       +RAU,SAMIOS,YAMAMOTO,GOLDBERG,+   (BNL,SYCR) IJ
BERGE    66 PR 147 945        +EBERHARD,HUBBARD,MERRILL,B-SHAFER,+  (LRL) I
MERRILL  66 UCRL-16455 THESIS D W MERRILL                           (LRL) JP
SHAFFR   66 PR 142 883        BUTTON-SHAFER,LINDSEY,MURRAY,SMITH    (LRL) JP
    --  A SPIN-PARITY DETERMINATION.

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Ξ(1630)

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                 21  XI*1/2(1630, JP=     ) I=1/2
                 21  XI*1/2(1630) MASS (MEV)   ------------------------

M        1628.0     5.0          APSELL    69 HBC  0  K-P 2.87 GEV/C    9/69*
M     PROBABLY SEEN              BARTSCH   69 HBC     K-P 10 GEV/C     10/69*

----------------  21  XI*1/2(1630) WIDTH (MEV)   ----------------------

W          15.0     5.0          APSELL    69 HBC  0                    9/69*

----------------  21  XI*1/2(1630) PARTIAL DECAY MODES   --------------

                                                            DECAY MASSES
P1          XI*1/2(1630) INTO XI PI                       1321+ 139

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                      REFERENCES -- XI*1/2(1630)

APSELL   69 PRL 23 884      +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS) I
BARTSCH  69 PL 28B 439      +     (AACHEN, BERLIN, CERN, LONDCN, VIENNA)

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Ξ(1700)

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                 51  XI*1/2(17CC, JP=     ) I=1/2
                 THIS RESONANCE IS NC LONGER THOUGHT TO EXIST.
                 51  XI*1/2(1700) MASS (MEV)   ------------------------

M       (1705.0)       APPROX     SMITH     65 HBC  0- K-P 2.1-.7 BEV/C

----------------  51  XI*1/2(1700) WIDTH (MEV)   ----------------------

W         (20.0)       APPROX     SMITH     65 HBC  0-

----------------  51  XI*1/2(1700) PARTIAL DECAY MODES   --------------

                                                            DECAY MASSES
P1          XI*1/2(1700) INTO XI PI                       1321+ 139
P2          XI*1/2(1700) INTO LAMBDA KBAR                 1115+ 497

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                      REFERENCES -- XI*1/2(1700)

SMITH    65 ATHENS CONF 251   G A SMITH, J S LINDSEY                (LRL) I

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Ξ(1820)

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                 50  XI*1/2(1820, JP=     ) I=1/2
                 50  XI*1/2(1820) MASS (MEV)   ------------------------

M       (1770.0)                 HALSTEINS 63 FBC  0- K-FR 3.5 BEV/C
M        1817.0     7.0          SMITH 1   65 HBC  0- K-P 2.4-.7 BEV/C
M        1814.0     4.0          BADIER    65 HBC  0  K-P 3 BEV/C
M        1830.0    10.0          ALITTI    69 HBC  -  K-P 3.9-5 BEV/C   9/69*
M        1801.0    13.0          APSELL    69 HBC  0  K-P 2.87 GEV/C    9/69*
M        . . . . . . . . . .
M   AVG  1815.5     3.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.1)

----------------  50  XI*1/2(1820) WIDTH (MEV)   ----------------------

W         (80.0)       OR LESS   HALSTEINS 63 FBC  0-
W          12.0     4.0          BADIER    65 HBC  0
W          30.0     7.0          SMITH 2   65 HBC  0-
W          55.0    40.0    20.0  ALITTI    69 HBC  -                    9/69*
W          78.0    33.0          APSELL    69 HBC  0                    9/69*
W        . . . . . . . . . .
W   AVG    17.6     7.7     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 2.3)

----------------  50  XI*1/2(1820) PARTIAL DECAY MODES   --------------

                                                            DECAY MASSES
P1          XI*1/2(1820) INTO LAMBDA KBAR                 1115+ 497
P2          XI*1/2(1820) INTO XI PI                       1321+ 139
P3          XI*1/2(1820) INTO SIGMA KBAR                  1197+ 497
P4          XI*1/2(1820) INTO XI*1/2(1530) PI             1530+ 139
P5          XI*(1820) INTO XI PI PI (XI PI NOT XI*(1530)) 1321+ 139+ 139

----------------  50  XI*1/2(1820) BRANCHING RATIOS   -----------------

R1          XI*1/2(1820) INTO (LAMBDA KBAR)/TOTAL          (P1)/TOTAL
R1            LARGE                BADIER    65 HBC                     7/66
R1            LARGE                SMITH 2   65 HBC                     7/66
R1             0.3       0.15      ALITTI    69 HBC  -                  9/69*

R2          XI*1/2(1820) INTO (XI PI)/TOTAL                (P2)/TOTAL
R2             0.1       0.1       ALITTI    69 HBC  -                  9/69*

R3          XI*1/2(1820) INTO (SIGMA KBAR)/TOTAL           (P3)/TOTAL
R3            (0.02)     OR LESS   TRIPP     67 RVUE                    8/67
R3             0.3       0.15      ALITTI    69 HBC  -                  9/69*

R4          XI*1/2(1820) INTO (XI*1/2(1530) PI)/TOTAL      (P4)/TOTAL
R4             0.3       0.15      ALITTI    69 HBC  -                  9/69*
R4            (0.25)   OR LESS     DAUBER    69 HBC     K-P 2.7 BEV/C   9/69*

R5          XI*1/2(1820) INTO (XI PI)/(LAMBDA KBAR)        (P2)/(P1)
R5             0.20      0.20      BADIER    65 HBC                     7/66
R5            SMALL                SMITH 2   65 HBC     IF XI*1933 EXIST 7/66

R6          XI*1/2(1820) INTO (XI*(1530) PI)/(LAM KBAR)    (P4)/(P1)
R6             0.26      0.13      SMITH 1   65 HBC
R6            SMALL                BADIER    65 HBC                     7/66

R7          XI*1/2(1820) INTO (XI PI PI)/(LAMBDA KBAR)     (P5)/(P1)
R7            (0.1)      CR MORE   SMITH 1   65 HBC
R7            SMALL                BADIER    65 HBC                     7/66

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                      REFERENCES -- XI*1/2(1820)

HALSTEIN 63 SIENA CONF 173   HALSTEINSLID,+ (BERGEN,CERN,EP,RTHF,UNICOL) I
SMITH 1  65 PRL 14 25        +LINDSEY,BUTTON-SHAFER,MURRAY          (LRL)IJP
BADIER   65 PL 16 171        +DEMOULIN,GOLDBERG, +       (EP,SACLAY,AMSTR) I
SMITH 2  65 ATHENS CONF 251  G A SMITH, J S LINDSEY                 (LRL)
TRIPP    67 NP B3 10         + LEITH, +     (LRL,SLAC,CERN,HEIDEL,SACLAY)
    --  USES DATA OF SMITH 1.
MERRILL  68 PR 167 1202      D W MERRILL, J BUTTON-SHAFER           (LRL)
    --  WEAK EVIDENCE CCNCERNING JP.

ALITTI   69 PRL 22 79        +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
DAUBER   69 PR 179 1262      +BERGE, HUBBARD, MERRILL, MULLER       (LRL)
APSELL   69 PRL 23 884       +     (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)

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Ξ(1930)

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                 52  XI*1/2(1930, JP=     ) I=1/2
                 52  XI*1/2(1930) MASS (MEV)   ------------------------

M     35 1933.0    16.0          BADIER    65 HBC  0  K-P 3 BEV/C
M     19 1930.0    20.0          ALITTI    68 HBC  0  K-P 4.6-5 BEV/C  11/68
M     66 1894.0    18.0          DAUBER    69 HBC  -  K-P 2.7 BEV/C    11/68
M        1962.0    14.0          APSELL    69 HBC  0  K-P 2.87 GEV/C    9/69*
M        . . . . . . . . . .
M   AVG  1934.4    14.3     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.7)
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Data in parentheses have not been included in our averages.

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-----------------  52  XI*1/2(1930) WIDTH (MEV)   -----------------------

W       35  140.0     35.0             BADIER    65 HBC  0
W       19   80.0     40.0             ALITTI    68 HBC  0                   11/68
W       66   98.0     23.0             DAUBER    69 HBC  -                   11/68
W           147.0     55.0             APSELL    69 HBC  0                    9/69*
W           . . . . . . . . . . .
W    AVG    108.7     16.5     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

-----------------  52  XI*1/2(1930) PARTIAL DECAY MODES    ---------------

                                                           DECAY MASSES
P1          XI*1/2(1930) INTO XI PI                     1321+ 139
P2          XI*1/2(1930) INTO LAMBDA KBAR               1115+ 497

-----------------  52  XI*1/2(1930) BRANCHING RATIOS    ------------------

R1          XI*1/2(1930) INTO XI PI                     (P1)
R1               SEEN                  BADIER    65 HBC  0
R1               SEEN                  ALITTI    68 HBC  0                   11/68
R1               SEEN                  DAUBER    69 HBC  -                   11/68

            LOOKED FOR BUT NOT SEEN IN OTHER CHANNELS.  SEE ALITTI 68.

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                                   REFERENCES -- XI*1/2(1930)
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BADIER    65 PL 16 171.          +DEMOULIN,GOLDBERG, +       (EP,SACLAY,AMST) I
ALITTI    68 PRL 21 1119         +FLAMINIO,METZGER,RADOJICIC,+(BNL,SYRACUSE) I
DAUBER    69 PR 179 1262         +BERGE, HUBBARD, MERRILL, MULLER        (LRL) I
APSELL    69 PRL 23 884          +      (BRANDEIS, MARYLAND, SYRACUSE, TUFTS)
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Ξ(2030)

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                 68  XI*1/2(2030, JP=   ) I=1/2

                 68  XI*1/2(2030) MASS (MEV)    -------------------------

M           2030.0     10.0            ALITTI    69 HBC  -  K-P 3.9-5 BEV/C   9/69*
M           2058.0     17.0            BARTSCH   69 HBC     K-P.10GEV/C       9/69*
M           . . . . . . . . . . .
M    AVG    2037.2     12.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.4)

-----------------  68  XI*1/2(2030) WIDTH (MEV)    -----------------------

W             45.0     40.0    20.0    ALITTI    69 HBC  -                    9/69*
W             57.0     30.0            BARTSCH   69 HBC                       9/69*
W           . . . . . . . . . . .
W    AVG      51.0     21.2    AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.0)

-----------------  68  XI*1/2(2030) PARTIAL DECAY MODES    ---------------

                                                           DECAY MASSES
P1          XI*1/2(2030) INTO XI PI                     1321+ 139
P2          XI*1/2(2030) INTO LAMBDA KBAR               1115+ 497
P3          XI*1/2(2030) INTO SIGMA KBAR                1197+ 497
P4          XI*1/2(2030) INTO XI*1/2(1530) PI           1530+ 139
P5          XI*1/2(2030) INTO LAMBDA (OR SIGMA) KBAR PI  1115+ 497+ 139

-----------------  68  XI*1/2(2030) BRANCHING RATIOS    ------------------

R1          XI*1/2(2030) INTO (XI PI)/(MODES P1 TO P4)    (P1)/(P1+P2+P3+P4)
R1            (0.30)   OR LESS         ALITTI    69 HBC  -  1 STD DEV LIMIT   9/69*

R2          XI*1/2(2030) INTO (LAM KBAR)/(MODES P1 TO P4) (P2)/(P1+P2+P3+P4)
R2             0.25     0.15           ALITTI    69 HBC  -                    9/69*

R3          XI*1/2(2030) INTO (SIG KBAR)/(MODES P1 TO P4) (P3)/(P1+P2+P3+P4)
R3             0.75     0.20           ALITTI    69 HBC  -                    9/69*

R4          XI*1/2(2030) INTO (XI* PI)/(MODES P1 THRU P4) (P4)/(P1+P2+P3+P4)
R4            (0.15)   OR LESS         ALITTI    69 HBC  -  1 STD DEV LIMIT   9/69*

R5      XI*1/2(2030) INTO LAMBDA (OR SIGMA) KBAR PI       (P5)
R5             SEEN                    BARTSCH   69 HBC                       9/69*

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                                   REFERENCES -- XI*1/2(2030)
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ALITTI    69 PRL 22 79           +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH   69 PL 28B 439          +     (AACHEN, BERLIN, CERN, LONDON, VIENNA)
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Ξ(2250)

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               22  XI*1/2(2250, JP=     )

               THE EVIDENCE FOR THIS RESONANCE IS WEAK.  IT IS SEEN
               AS A BUMP OF NOT MUCH STATISTICAL SIGNIFICANCE IN
               (LAMBDA KBAR PI), (SIGMA KBAR PI), AND (XI PI PI) IN-
    VARIANT-MASS DISTRIBUTIONS.

-----------------  22  XI*   (2250) MASS (MEV)    -----------------------

M          2244.0     52.0             BARTSCH   69 HBC     K-P 10 GEV/C      9/69*

-----------------  22  XI*   (2250) WIDTH (MEV)    ----------------------

W           130.0     80.0             BARTSCH   69 HBC                       9/69*

-----------------  22  XI*1/2(2250) PARTIAL DECAY MODES    ---------------

                                                           DECAY MASSES
P1       XI*1/2(2250) INTO XI PI PI                     1321+ 139+ 139
P2       XI*1/2(2250) INTO LAMBDA KBAR PI               1115+ 497+ 139
P3       XI*1/2(2250) INTO SIGMA KBAR PI                1197+ 497+ 139

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                              REFERENCES -- XI*   (2250)
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BARTSCH   69 PL 28B 439          +     (AACHEN, BERLIN, CERN, LONDON, VIENNA)
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****** ********* ********* ********* ********* ********* ********* *******
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Ξ(2500)

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               99  XI*1/2(2500, JP=     ) I=1/2

               IT IS QUITE POSSIBLE THAT THE REASON THE EXPERIMENTS
               DISAGREE ABOUT THE MASS AND WIDTH IS THAT THEY ARE
               SEEING DIFFERENT XI*S.  FOR NOW, HOWEVER, WE GROUP
    THEM TOGETHER.

-----------------  99  XI*1/2(2500) MASS (MEV)    -----------------------

M         (2430.0)   (20.0)            ALITTI    69 HBC  -  K-P 4.6-5 GEV/C   9/69*
M          2500.0     10.0             BARTSCH   69 HBC  0- K-P 10 GEV/C      9/69*

-----------------  99  XI*1/2(2500) WIDTH (MEV)    ----------------------

W           150.0     60.0     40.0    ALITTI    69 HBC  -                    9/69*
W            59.0     27.0             BARTSCH   69 HBC  0-                   9/69*
W          . . . . . . . . . . .
W    AVG     79.5     38.0     AVERAGE (ERROR INCLUDES SCALE FACTOR OF 1.6)

-----------------  99  XI*1/2(2500) PARTIAL DECAY MODES    --------------

                                                           DECAY MASSES
P1          XI*1/2(2500) INTO XI PI                     1321+ 139
P2          XI*1/2(2500) INTO LAMBDA KBAR               1115+ 497
P3          XI*1/2(2500) INTO SIGMA KBAR                1197+ 497
P4          XI*1/2(2500) INTO XI*1/2(1530) PI           1530+ 139
P5          XI*1/2(2500) INTO LAMBDA (OR SIGMA) KBAR PI  1115+ 497+ 139
P6          XI*1/2(2500) INTO XI PI PI                  1321+ 139+ 139

-----------------  99  XI*1/2(2500) BRANCHING RATIOS    ----------------

R1       XI*1/2(2500) INTO (XI PI)/(MODES P1 THRU P4)      (P1)/(P1+P2+P3+P4)
R1             (0.5)OR LESS            ALITTI    69 HBC     1 STD DEV LIMIT   9/69*

R2       XI*1/2(2500) INTO (LAM KBAR)/(MODES P1 THRU P4)   (P2)/(P1+P2+P3+P4)
R2              0.5       0.2          ALITTI    69 HBC  -                    9/69*

R3       XI*1/2(2500) INTO (SIG KBAR)/(MODES P1 THRU P4)   (P3)/(P1+P2+P3+P4)
R3              0.5       0.2          ALITTI    69 HBC  -                    9/69*

R4       XI*1/2(2500) INTO (XI* PI)/(MODES P1 THRU P4)     (P4)/(P1+P2+P3+P4)
R4             (0.2)OR LESS            ALITTI    69 HBC     1 STD DEV LIMIT   9/69*

R5       XI*1/2(2500) INTO LAMBDA (OR SIGMA) KBAR PI       (P5)
R5             SEEN                    BARTSCH   69 HBC  0-                   9/69*

R6       XI*1/2(2500) INTO XI PI PI                        (P6)
R6             SEEN                    BARTSCH   69 HBC  0-                   9/69*

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                                   REFERENCES -- XI*1/2(2500)
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ALITTI    69 PRL 22 79           +BARNES,FLAMINIO,METZGER, +  (BNL,SYRACUSE) I
BARTSCH   69 PL 28B 439          +     (AACHEN, BERLIN, CERN, LONDON, VIENNA)
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Ω^-

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               24  OMEGA -  (1675, JP=3/2+)  I=0

               SEE LISTINGS OF STABLE PARTICLES

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APPENDIX I. Test of $\Delta I=1/2$ Rule for K Decays

The quantities of interest for making tests of theoretical predictions regarding the $\Delta I=1/2$ rule for K decay are usually partial decay rates for single channels or special sums of channels. It is not possible to compute the errors on sums, differences, and ratios of partial decay rates from the information given in the Table of Stable Particles because of the presence of off-diagonal terms in the error matrix. For this reason we give some of these quantities below.

Table I.

(000) or (+-0) refer to the sign of the pions into which the K decays.

$\Gamma_{K^+_{\ell 3}} = \Gamma_{K^+_{e3}} + \Gamma_{K^+_{\mu 3}}$	$=(6.50\pm.12)\times 10^6 \text{sec}^{-1}$
$\Gamma_{K^+_\tau} - \Gamma_{K^+_{\tau}}$	$=(3.135\pm.044)\times 10^6 \text{sec}^{-1}$
$\Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}}$	$= 0.656\pm.023$
$\Gamma_{K^+_\tau} / \Gamma_{K^+_\tau}$	$= 3.28\pm.09$
$\Gamma_{K^0_{\ell 3}} = \Gamma_{K^0_{e3}} + \Gamma_{K^0_{\mu 3}}$	$=(12.20\pm.45)\times 10^6 \text{sec}^{-1}$
$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}}$	$= 0.689\pm.028$
$\Gamma_{K^0(000)} / \Gamma_{K^0(+-0)}$	$= 1.703\pm.075$

1. Leptonic decay rates

The $\Gamma_{K_{\ell 3}}$ rates are useful in testing the leptonic $\Delta I = 1/2$ rule in the way suggested by Trilling.[1] The predictions are

$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 1.012$, a phase-space factor,[2] and

$$\Gamma_{K^0_{\mu 3}} / \Gamma_{K^0_{e3}} = \Gamma_{K^+_{\mu 3}} / \Gamma_{K^+_{e3}} .$$

From Table I,

$$\Gamma_{K^0_{\ell 3}} / 2\Gamma_{K^+_{\ell 3}} = 0.94\pm0.04$$

and

$$\frac{\Gamma_{K^0_{\mu 3}}}{\Gamma_{K^0_{e3}}} \left[\frac{\Gamma_{K^+_{\mu 3}}}{\Gamma_{K^+_{e3}}}\right]^{-1} = 1.05\pm.06$$

These results seem to show a less than 2σ disagreement with the predictions, but the errors should be regarded with caution in view of the internal disagreements in the data. (Note the ideograms in the data listing for the charged K meson.)

2. Three-pion decays

We follow here the tests done by Mast et al.,[3] based on the general analysis of K decays suggested by Zemach.[4] Both decay rates and slopes (energy dependence of the Dalitz plot distributions) are used. The $\Delta I = 1/2$ rule gives the following predictions:

$$T_1 = \frac{2}{3} \frac{\Gamma_{K^0(000)}}{\phi_1} \left[\frac{\Gamma_{K^0(+-0)}}{\phi_2}\right]^{-1} = 1 ,$$

$$T_2 = \frac{1}{4} \frac{\Gamma_{K^+_\tau}}{\phi_3} \left[\frac{\Gamma_{K^+_{\tau'}}}{\phi_4}\right]^{-1} = 1 ,$$

$$T_3 = \frac{1}{2} \frac{\Gamma_{K^+_\tau}}{\phi_3} \left[\frac{\Gamma_{K^0(+-0)}}{\phi_2}\right]^{-1} = 1 ,$$

$$T_4 = \frac{1}{2} g_{K^+_{\tau'}} + g_{K^+_\tau} = 0 ,$$

where the ϕ_i are the phase space factors. Mast et al.[3] have calculated these factors by use of a relativistic formulation and the masses from this compilation. The factors labeled UDP are the relative areas of the Dalitz plots, assuming a uniform distribution. The NUDP include the observed slopes (see below). The CNUDP have been calculated by including the final-state Coulomb interaction. The values are:

	Method		
	UDP	NUDP	CNUDP
$\phi_1(000) =$	1.487	1.487	1.451
$\phi_2(+-0) =$	1.219	1.268	1.268
$\phi_3(++-) =$	1.000	1.000	1.000
$\phi_4(+00) =$	1.247	1.184	1.155

The slopes for the various decays have not been tabulated in the Stable Particles Table. They are as follows:

$$\left.\begin{array}{l} g_{K_\tau^+} = -0.206\pm0.009 \\ g_{K_\tau^-} = -0.194\pm0.007 \end{array}\right\} -0.198\pm0.006,$$

$$g_{K_{\tau'}^+} = 0.511\pm0.018,$$

$$g_{K_L^0(+-0)} = 0.400\pm0.033\ .$$

A difference in the τ^+ and τ^- slopes would be an indication of CP violation in this decay. Since no difference is present at this time, we average the two and use this value in T_4.

Using the CNUDP and rates and slopes reported here we get:

$$T_1 = 0.002\pm0.044,$$
$$T_2 = 0.947\pm0.026,$$
$$T_3 = 1.22\pm0.050,$$
$$T_4 = 0.058\pm0.019\ .$$

The three-pion final state can be in isospin states I = 1, 2, 3. T_1 and T_2 test the existence of isospin I = 3 in the final state and are consistent with no or very little I = 3. T_4 is related to the I = 2 amplitude in the final state and indicates, within three standard deviations, the presence of some I = 2. T_3, finally, gives information on the $\Delta I = 3/2$ part of the I = 1 amplitude relative to the $\Delta I = 1/2$ part and seems to be the largest violation of all.

More information can be drawn by comparing the slopes; for this we refer the reader to the paper by Mast et al.[3]

References

1. G. Trilling, K-Meson Decays, UCRL-16473 (updated from Argonne Conference Proceedings, 1965, p. 115).

2. N. Brene (CERN), private communication. In our Jan. 1968 edition we had erroneously used 1.04.

4. T. S. Mast, L. K. Gershwin, M. Alston-Garnjost, R. O. Bangerter, A. Barbaro-Galtieri, J. J. Murray, F. T. Solmitz, and R. D. Tripp, Phys. Rev. 183, 1200 (1969).

4. C. Zemach, Phys. Rev. 133, B1201 (1964).

Appendix II

A. SU(3) CLASSIFICATION OF BARYON RESONANCES

There are a few multiplets that have been studied and we report here the results. The relevant formulae are given below.

Mass Formulae

Decuplet	$\Delta-\Sigma=\Sigma-\Xi^*=\Xi^*-\Omega$	GMO	(1)
Octet	$2(N+\Xi)=3\Lambda+\Sigma$	GMO	(2)
Nonet	$\sin^2\theta = \dfrac{\Lambda-M_8}{\Lambda-\Lambda'}$	Mixing angle	(3)
	$M_8 = \dfrac{2(N+\Xi)-\Sigma}{3}$	GMO	(4)

Here GMO stands for the Gell-Mann-Okubo formula; the particle symbol indicates its mass. The formulae would be the same if squared masses were used. For the nonet case, Λ is the "mostly-octet" particle, Λ' is the "mostly-singlet" particle.

Decay Rates

In terms of a relativistically invariant matrix element T, the decay rate for two-body decay of a resonance of mass M_R is

$$\Gamma = \frac{|T|^2 R_2}{M_R}\ , \qquad (5)$$

where $R_2 = k/M_R$ is the two-body phase space factor. Since the numerator is an invariant, and since Γ must transform as $1/E$, we introduce the denominator $1/M_R$ (see FEYNMAN 62).

For meson decays (see below) the rates are calculated according to Eq. (1); for baryon resonance decays into $1/2^+$ baryons and 0^- mesons, one next takes into account the fact that spin sums in $|T|^2$ introduce another factor M_R, cancelling the $1/M_R$. We are then left with

$$\Gamma = \frac{|T|^2 k}{M_R} \text{ for baryons} \qquad (5')$$

$$= \frac{|T|^2 k}{M_R^2} \text{ for mesons}\ . \qquad (5'')$$

In Eqs. (6) and (7) below, $|T|^2$ is dimensionless, so we tidy up the dimensions by introducing a factor of mass M_N (or M_N^2 for mesons), where M_N is conventionally taken to be the nucleon mass.

$|T|^2$ contains centrifugal barrier factors, which we call B_ℓ. We then have

$$\left.\begin{matrix}\text{Decuplet}\\ \text{Singlet}\end{matrix}\right\} \quad \Gamma = (cg)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (6)$$

$$\text{Octet} \quad \Gamma = (c_D g_D + c_F g_F)^2 B_\ell(k) \frac{M_N}{M_R} k \qquad (7)$$

$$\text{Nonets} \quad \begin{cases} G_8 = \Lambda \cos\theta - \Lambda' \sin\theta \\ G_1 = \Lambda \sin\theta + \Lambda' \cos\theta \end{cases} \qquad (8)$$

$$\text{with} \quad \begin{matrix} G_8 = c_D g_D + c_F g_F \\ G_1 = c_1 g_1 . \end{matrix} \qquad (9)$$

Here B_ℓ are the centrifugal barrier factors given by Blatt-Weisskopf (1952), the c_i are the SU(3) coefficients with the sign convention adopted in this article [see long caption for the table of SU(3) isoscalar coefficients], M_N is the nucleon mass, M_R is the resonance mass for which Γ is calculated, k is the center-of-mass momentum for the channel being considered, g_i are the relevant couplings. For the case of singlet-octet mixing, formula (8) has to be used in conjunction with (6) and (7). G_8 and G_1 represent the couplings for the multiplet, and Λ and Λ' represent the couplings for the physical states.

The relation between g_D, g_F and the D (symmetric) and F (antisymmetric) couplings is as follows:

$$\frac{F}{D} = \sqrt{\frac{5}{3}} \quad \frac{g_F}{g_D} . \qquad (10)$$

Table I shows the situation. We now discuss each multiplet in detail.

$\frac{1}{2}^-$-Nonet (Baryon-Eta Resonances)

We report here the results of Tripp (1969). The mixing angle θ as well as the first F/D ratio have been calculated by using the Λ(1670) and Λ(1405) decay rates. Relation (7) was multiplied by the factor $\left[\frac{M_R - M_B}{\overline{M}_R - \overline{M}_B}\right]^2$, where M_B is the decay baryon and $\overline{M}_R - \overline{M}_B = 564$ MeV is the difference of the mean $1/2^-$ and $1/2^+$ baryon octet masses. This factor has been suggested by Gell-Mann et al. (Gell-Mann, 1968). The second F/D ratio was calculated by using the N(1535) decay rates. Using the mass formulae (3) and (4) with 19 deg mixing angle, the mass for the Ξ member of the octet falls at M = 1818 MeV (not observed).

$3/2^-$ Nonet

The mixing angle is from Levi Setti (1969), calculated by using the Λ(1690) and Λ(1520) decay rates. The F/D ratio is from Tripp (1968), taken to be the most likely value for the interception of the lines in the plot of g_F vs g_D for all the members of the octet. The mixing angle, calculated by using the mass formula and assuming Ξ(1820) to be a member of this multiplet, is 20 deg. The decay rates for Ξ(1820) are in agreement with the decay rates of the other members of the multiplet.

$5/2^-$ and $5/2^+$ Octets

The F/D ratio is taken from Tripp (1968), again as the intersection in the plot of g_F vs g_D for the decay rates measured (see Baryon Table).

$3/2^+$ and $7/2^+$ Decuplets

Tripp (1968) has calculated the value of g^2 for the various members of these decuplets. The value of g^2 should be common to all decays, but it appears to be significantly different.

B. SU(3) CLASSIFICATION OF MESON RESONANCES

All of the discussion above applies, except that for Bosons the GMO formula is usually applied to the square of the masses, as opposed to the first power for fermions. Thus for example, Eq. (2) becomes

$$4\hat{K} = 3\hat{\eta} + \hat{\pi}. \qquad (2')$$

The symbol $\hat{K}$ was introduced by Glashow and Socolow † for the square of the $\hat{K}$ mass, etc.

Because of the difference between Eqs. (5') and (5''), there is also an extra factor of (M_N/M_R) in Eqs. (6) and (7).

For mesons there are only three established nonets: 0^-, 1^-, and 2^+, so it has been possible to crowd a small note about them at the bottom of the footnotes to the meson table.

Table I. SU(3) baryon multiplets with two or more known members. The coupling constants are those for decay into baryon ($1/2^+$) octet ⊗ pseudoscalar meson octet.

J^P	Octet members				Singlet	θ(degrees)	F/D	g_D [a]
$1/2^-$	N' (1535)	Λ (1670)	Σ (1750)	Ξ (1818)?	Λ (1405	19	-1.77 or -1.98	0.42 0.45
$3/2^-$	N(1530)	Λ (1690)	Σ (1670)	Ξ (1820)?	Λ (1520)	-18±3	1.19	0.34
$5/2^-$	N(1670)	Λ (1830)	Σ (1765)				-0.13	0.77
$5/2^+$	N(1688)	Λ (1815)	Σ (1915)				1.06	0.56
	Decuplet members				g_{10}^2			
$3/2^+$	Δ (1236)	Σ (1385)	Ξ (1530)	Ω^-	0.94 to 2.38			
$7/2^+$	Δ (1950)	Σ (2030)			0.25 to 0.97			

a. Using formula (10) one can derive g_F.

Footnotes and References for SU(3) Classification

† The formula has been calculated from analogy with the formula for mixing of meson states, first put in this form by S. L. Glashow and R. H. Socolow, Phys. Rev. Letters 15, 329 (1966). For the baryon formula see A. Barbaro-Galtieri, Phenomenology of Resonances and Particle Supermultiplets, UCRL-17054 (1966).

• J. M. Blatt and V. F. Weisskopf, Theoretical Nuclear Physics, Wiley, New York (1952).

• M. Gell-Mann, R. Oakes, and B. Renner, Phys. Rev. 175, 2195 (1968).

• R. D. Tripp, in Proceedings of the 14th International Conference on High Energy Physics, Vienna, 1968, p. 173.

• R. Levi Setti, in Proceedings of the Lund International Conference on Elementary Particles (1969).

• R. D. Tripp, Proceedings of the 3rd Hawaiian Topical Conference on Particle Physics, UCRL-19361 (1969).

• R. P. Feynman, Theory of Fundamental Processes, W. A. Benjamin, Inc., New York, 1962.

Special Relativity

Notation. 4-vector in c.m. $p = (w, \vec{p})$; in lab $P = (W, \vec{P})$, $T = W - m$.
Solid-angle element $d\omega = 2\pi d\cos\theta$; $d\Omega = 2\pi d\cos\Theta$.
$p^2 = w^2 - \vec{p}^2 = m^2$ is an invariant. Cross section σ is invariant.

Lorentz Transformation

$$\begin{pmatrix} w \\ p_x \\ p_y \\ p_z \end{pmatrix} = \begin{pmatrix} \bar\gamma & -\bar\eta & 0 & 0 \\ -\bar\eta & \bar\gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} W \\ P_x \\ P_y \\ P_z \end{pmatrix}$$

If θ and Θ are measured with respect to the transformation axis x,

$$\frac{P_\perp}{P_x} = \tan\theta = \frac{P\sin\Theta}{-\bar\eta W + \bar\gamma P\cos\Theta} \quad (1)$$

If particle 1 is beam, 2 is target, $(W_2, \vec{P}_2) = (m_2, \vec{0})$ and
$\bar\gamma = (W_1 + m_2)/\sqrt{s}$, $\bar\eta = \bar\gamma\bar\beta = |\vec{P}_1|/\sqrt{s}$, $|\vec{p}_1| = |\vec{p}_2| = \bar\eta m_2 = |\vec{P}_1| m_2/\sqrt{s}$. (2)
For $m_1 = m_2$, $\bar\gamma^2 = 1 + T_1/2m_1$.

General Lorentz Transformation (characterized by $\vec\beta$, with $\bar\gamma = (1-\vec\beta^2)^{-1/2}$, $\vec\eta = \bar\gamma\vec\beta$):
$w = \bar\gamma W - \vec\eta\cdot\vec{P}$; $\vec{p} = \vec{P} - \vec\eta\,\frac{W+w}{\bar\gamma + 1}$

Invariants. Notation: $1 + 2 \to 1' + 2'$.

$s = (p_1 + p_2)^2 = m_1^2 + m_2^2 + 2(w_1w_2 - \vec{p}_1\cdot\vec{p}_2)$ (3)

$t = (p_i' - p_i)^2 = m_i^2 + m_i'^2 - 2(w_iw_i' - \vec{p}_i\cdot\vec{p}_i')$ (i = 1, 2) (4)

$u = (p_1' - p_2)^2 = (p_2' - p_1)^2$ (5)

General relation: $s + t + u = m_1^2 + m_1'^2 + m_2^2 + m_2'^2$. (6)

In lab system $P_2 = (m_2, \vec{0})$, and writing $W = m + T$

$s = m_1^2 + m_2^2 + 2W_1m_2 = (m_1 + m_2)^2 + 2T_1m_2$ (3, lab)

$t = m_2^2 + m_2'^2 - 2W_2'm_2 = (m_2 - m_2')^2 - 2T_2'm_2$ (4, lab)

In c.m. system $dt = +2|\vec{p}_i|\,|\vec{p}_i'|\,d\cos\theta$ (4, cm)

For elastic scattering ($m_1 = m_1'$, $m_2 = m_2'$), (4) in c.m. simplifies to
$t = -2\vec{p}^2(1-\cos\theta) = -4\vec{p}^2\sin^2\theta/2$ (4, el)

$u = (m_1^2 - m_2^2)^2/s - 2\vec{p}^2(1+\cos\theta) = (m_1^2 - m_2^2)^2/s - 4\vec{p}^2\cos^2\theta/2$

For elastic scattering, using (4, lab), (4, el), and (2),

$T_2' = \frac{2\vec{P}_1^2 m_2}{s}\sin^2\left(\frac{\theta}{2}\right)$ (useful for calculating δ-ray energies). (7)

Two-Body States. Energies and momenta in c.m.

$w_1 = \frac{s + m_1^2 - m_2^2}{2\sqrt{s}}$, $\vec{p}_1^2 = \vec{p}_2^2 = \frac{1}{4s}[s - (m_1+m_2)^2][s - (m_1 - m_2)^2]$. (8)

3- and 4-Body States. Let $m_{ij}^2 = (p_i + p_j)^2$, etc., then

$\sum_{i<j} m_{ij}^2 = \Sigma m_i^2 + m_{123}^2 = \text{const.}$ (i, j = 1, 2, 3) (follows from (6)). (9)

$= 2\Sigma m_i^2 + m_{1234}^2 = \text{const.}$

$\sum_{i<j<k} m_{ijk}^2 = \Sigma m_i^2 + 2m_{1234}^2 = \text{const.}$ (i, j, k = 1, 2, 3, 4.) (10)

R_n, Invariant Volume in n-Body Momentum Space

A useful invariant is $\int d^4p\,\delta(p^2 - m^2) = \frac{d^3\vec{p}}{2w} = \frac{\vec{p}^2 d|\vec{p}|d\omega}{2w} = \frac{1}{2}|\vec{p}|\,dw\,d\omega$.

$R_2 = \pi|\vec{p}_1|/\sqrt{s}$, $R_3 = \pi^2\int dw_1dw_2 = (\pi^2/4s)\int dm_{12}^2\,dm_{23}^2$ (using c.m. quantities)

Recurrence Relation for Factoring R_n (see e.g., Hagedorn, p. 93[a])

Write $N \to 1, 2, \ldots k, k+1, \ldots n$ (R_n) then
as $N \to K, k+1, \ldots n$ (R_{n-k+1}); $K \to 1, 2, \ldots k$ (R_k) — $R_n = \int d(m_K^2) R_k R_{n-k+1}$

Cross Section (or Decay Rate)

For $1 + 2 \to n$ particles (or $1 \to n$ particles)
$\sigma F = |M|^2 R_n$ (or $\Gamma w_1 = |M|^2 R_n$)
where M is an invariant matrix element.
F is (Møller's) invariant flux factor, $F^2 = (p_1p_2)^2 - m_1^2m_2^2$.
In every system where $\vec{p}_1$ and $\vec{p}_2$ are collinear, $F = w_1w_2|\vec{v}_1 - \vec{v}_2|$ ($\vec{v} = \vec{p}/w$).
If particle 1 is beam, 2 is target ($\vec{P}_2 = 0$), $F = |\vec{P}_1|m_2 = |\vec{p}_1|\sqrt{s}$ [cf. (2)].
The rate (= number per unit 4-dimensional volume $d^4r = dt\,d^3\vec{r}$) is
$d^4N/d^4r = \sigma\rho_1\rho_2|\vec{v}_1 - \vec{v}_2|$, ρ_i = volume density of particles (i = 1, 2).

a. R. Hagedorn, Relativistic Kinematics, (W. A. Benjamin, New York, 1964).

C. M. Energy (μ) and Momentum (P_{CMS}) vs. Beam Momentum (P) of e, π, K, or p on p

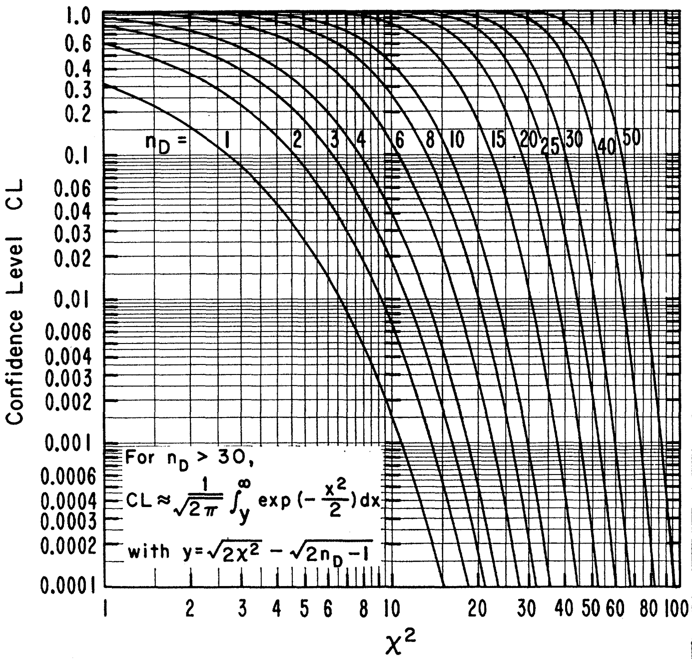
$\mu d\mu = m_p dE = m_p v_{beam,lab}\, dP \approx m_p dP$

P(LAB) (MEV/C)	INVARIANT MASS (MEV) ep	πp	Kp	pp	P(CMS) (MEV/C) ep	πp	Kp	pp
0	939	1078	1432	1877	0	0	0	0
20	958	1079	1432	1877	20	17	13	10
40	977	1083	1433	1877	38	35	26	20
60	996	1089	1434	1877	56	52	39	30
80	1015	1096	1436	1878	74	68	52	40
T(PI) = PLAB - 59 MEV								
100	1033	1105	1439	1879	91	85	65	50
120	1051	1116	1441	1880	107	101	78	60
140	1069	1127	1445	1882	123	117	91	70
160	1087	1139	1449	1883	138	132	104	80
180	1104	1152	1453	1885	153	147	116	90
T(PI) = PLAB - 92 MEV								
200	1121	1165	1457	1887	167	161	129	99
220	1137	1178	1462	1889	182	175	141	109
240	1154	1192	1468	1892	195	189	153	119
260	1170	1206	1474	1894	209	202	166	129
280	1186	1219	1480	1897	222	215	178	138
T(PI) = PLAB - 107 MEV								
300	1201	1233	1486	1900	234	228	189	148
320	1217	1247	1493	1903	247	241	201	158
340	1232	1261	1500	1906	259	253	213	167
360	1247	1274	1507	1910	271	265	224	177
380	1262	1288	1514	1913	282	277	235	186
T(PI) = PLAB - 115 MEV								
400	1277	1302	1522	1917	294	288	247	196
420	1292	1315	1530	1921	305	300	258	205
440	1306	1329	1538	1925	316	311	268	214
460	1320	1342	1546	1929	327	322	279	224
480	1335	1356	1554	1933	337	332	290	233
T(PI) = PLAB - 120 MEV								
500	1349	1369	1563	1938	348	343	300	242
520	1362	1382	1572	1943	358	353	310	251
540	1376	1395	1580	1947	368	363	321	260
560	1390	1408	1589	1952	378	373	331	269
580	1403	1421	1598	1957	388	383	341	278
T(PI) = PLAB - 123 MEV								
600	1416	1434	1607	1962	397	393	350	287
620	1430	1446	1616	1967	407	402	360	296
640	1443	1459	1625	1973	416	412	370	304
660	1456	1472	1634	1978	425	421	379	313
680	1468	1484	1644	1984	434	430	388	322
T(PI) = PLAB - 125 MEV								
700	1481	1496	1653	1989	443	439	397	330
720	1494	1509	1662	1995	452	448	406	339
740	1506	1521	1671	2001	461	457	415	347
760	1519	1533	1681	2007	470	465	424	355
780	1531	1545	1690	2013	478	474	433	364
T(PI) = PLAB - 127 MEV								
800	1543	1557	1699	2019	486	482	442	372
820	1555	1569	1709	2025	495	490	450	380
840	1567	1580	1718	2031	503	499	459	388
860	1579	1592	1728	2037	511	507	467	396
880	1591	1604	1737	2043	519	515	475	404
T(PI) = PLAB - 129 MEV								
900	1603	1615	1747	2049	527	523	483	412
920	1615	1627	1756	2056	535	531	492	420
940	1626	1638	1765	2062	542	538	500	428
960	1638	1649	1775	2069	550	546	508	435
980	1649	1661	1784	2075	558	554	515	443
T(PI) = PLAB - 130 MEV								
1000	1660	1672	1794	2082	565	561	523	451
1020	1672	1683	1803	2088	573	569	531	458
1040	1683	1694	1812	2095	580	576	538	466
1060	1694	1705	1822	2102	587	583	546	473
1080	1705	1716	1831	2108	594	591	553	481
T(PI) = PLAB - 131 MEV								
1100	1716	1726	1840	2115	601	598	561	488
1120	1727	1737	1850	2122	609	605	568	495
1140	1738	1748	1859	2129	616	612	575	502
1160	1748	1758	1868	2135	622	619	583	510
1180	1759	1769	1877	2142	629	626	590	517
T(PI) = PLAB - 131 MEV								
1200	1770	1780	1887	2149	636	633	597	524
1220	1780	1790	1896	2156	643	639	604	531
1240	1791	1800	1905	2163	650	646	611	538
1260	1801	1811	1914	2170	656	653	618	545
1280	1812	1821	1923	2177	663	660	624	552
T(PI) = PLAB - 132 MEV								
1300	1822	1831	1932	2184	669	666	631	559
1320	1832	1841	1941	2191	676	673	638	565
1340	1843	1851	1950	2198	682	679	645	572
1360	1853	1862	1959	2205	689	685	651	579
1380	1863	1872	1968	2212	695	692	658	585
T(PI) = PLAB - 133 MEV								

P(LAB) (MEV/C)	INVARIANT MASS (MEV) ep	πp	Kp	pp	P(CMS) (MEV/C) ep	πp	Kp	pp
1400	1873	1881	1977	2219	701	698	664	592
1420	1883	1891	1986	2226	708	704	671	599
1440	1893	1901	1995	2233	714	711	677	605
1460	1903	1911	2004	2240	720	717	684	612
1480	1912	1921	2013	2247	726	723	690	618
T(PI) = PLAB - 133 MEV								
1500	1922	1930	2022	2254	732	729	696	624
1520	1932	1940	2031	2261	738	735	702	631
1540	1942	1950	2039	2268	744	741	709	637
1560	1951	1959	2048	2275	750	747	715	643
1580	1961	1969	2057	2282	756	753	721	650
T(PI) = PLAB - 133 MEV								
1600	1970	1978	2065	2289	762	759	727	656
1620	1980	1988	2074	2296	768	765	733	662
1640	1989	1997	2083	2304	773	770	739	668
1660	1999	2006	2091	2311	779	776	745	674
1680	2008	2016	2100	2318	785	782	751	680
T(PI) = PLAB - 134 MEV								
1700	2018	2025	2109	2325	791	788	756	686
1720	2027	2034	2117	2332	796	793	762	692
1740	2036	2043	2126	2339	802	799	768	698
1760	2045	2053	2134	2346	807	805	774	704
1780	2054	2062	2143	2353	813	810	779	710
T(PI) = PLAB - 134 MEV								
1800	2064	2071	2151	2360	818	816	785	716
1820	2073	2080	2159	2367	824	821	791	721
1840	2082	2089	2168	2374	829	827	796	727
1860	2091	2098	2176	2381	835	832	802	733
1880	2100	2107	2184	2388	840	837	808	739
T(PI) = PLAB - 134 MEV								
1900	2108	2115	2193	2395	845	843	813	744
1920	2117	2124	2201	2402	851	848	818	750
1940	2126	2133	2209	2409	856	853	824	756
1960	2135	2142	2217	2416	861	859	829	761
1980	2144	2150	2226	2423	867	864	835	767
T(PI) = PLAB - 135 MEV								
2000	2153	2159	2234	2430	872	869	840	772
2020	2161	2168	2242	2437	877	874	845	778
2040	2170	2176	2250	2444	882	879	851	783
2060	2179	2185	2258	2451	887	885	856	789
2080	2187	2194	2266	2458	892	890	861	794
T(PI) = PLAB - 135 MEV								
2100	2196	2202	2274	2465	897	895	866	799
2120	2204	2211	2282	2472	902	900	872	805
2140	2213	2219	2290	2479	907	905	877	810
2160	2221	2227	2298	2486	912	910	882	815
2180	2230	2236	2306	2493	917	915	887	821
T(PI) = PLAB - 135 MEV								
2200	2238	2244	2314	2500	922	920	892	826
2220	2246	2253	2322	2507	927	925	897	831
2240	2255	2261	2330	2514	932	930	902	836
2260	2263	2269	2338	2520	937	934	907	841
2280	2271	2277	2346	2527	942	939	912	846
T(PI) = PLAB - 135 MEV								
2300	2280	2286	2353	2534	947	944	917	852
2320	2288	2294	2361	2541	951	949	922	857
2340	2296	2302	2369	2548	956	954	927	862
2360	2304	2310	2377	2555	961	959	932	867
2380	2312	2318	2384	2561	966	963	937	872
T(PI) = PLAB - 135 MEV								
2400	2320	2326	2392	2568	970	968	941	877
2420	2328	2334	2400	2575	975	973	946	882
2440	2336	2342	2407	2582	980	977	951	887
2460	2344	2350	2415	2589	984	982	956	892
2480	2352	2358	2423	2595	989	987	960	897
T(PI) = PLAB - 136 MEV								
2500	2360	2366	2430	2602	994	991	965	901
2520	2368	2374	2438	2609	998	996	970	906
2540	2376	2382	2445	2616	1003	1001	975	911
2560	2384	2390	2453	2622	1007	1005	979	916
2580	2392	2398	2460	2629	1012	1010	984	921
T(PI) = PLAB - 136 MEV								
2600	2400	2405	2468	2636	1017	1014	988	926
2620	2408	2413	2475	2643	1021	1019	993	930
2640	2415	2421	2483	2649	1025	1023	998	935
2660	2423	2429	2490	2656	1030	1028	1002	940
2680	2431	2436	2498	2663	1034	1032	1007	944
T(PI) = PLAB - 136 MEV								
2700	2439	2444	2505	2669	1039	1037	1011	949
2720	2446	2452	2512	2676	1043	1041	1016	954
2740	2454	2459	2520	2682	1048	1045	1020	958
2760	2462	2467	2527	2689	1052	1050	1025	963
2780	2469	2474	2534	2696	1056	1054	1029	968
T(PI) = PLAB - 136 MEV								

P(LAB) (MEV/C)	INVARIANT MASS (MEV) πp, ep	Kp	pp	P(CMS) (MEV/C) πp, ep	Kp	pp
3.0	2.56	2.61	2.77	1.10	1.08	1.02
3.2	2.63	2.68	2.83	1.14	1.12	1.06
3.4	2.70	2.75	2.89	1.18	1.16	1.10
3.6	2.77	2.82	2.96	1.22	1.20	1.14
3.8	2.83	2.88	3.02	1.26	1.24	1.18
T(PI) = PLAB - .137 GEV						
4.0	2.90	2.95	3.08	1.29	1.27	1.22
4.2	2.96	3.01	3.14	1.33	1.31	1.26
4.4	3.03	3.07	3.19	1.36	1.34	1.29
4.6	3.09	3.13	3.25	1.40	1.38	1.33
4.8	3.15	3.19	3.31	1.43	1.41	1.36
T(PI) = PLAB - .138 GEV						
5.0	3.21	3.25	3.36	1.46	1.44	1.40
5.2	3.27	3.31	3.42	1.49	1.48	1.43
5.4	3.32	3.36	3.47	1.53	1.51	1.46
5.6	3.38	3.42	3.52	1.56	1.54	1.49
5.8	3.43	3.47	3.58	1.59	1.57	1.52
T(PI) = PLAB - .138 GEV						
6.0	3.49	3.52	3.63	1.61	1.60	1.55
6.2	3.54	3.58	3.68	1.64	1.63	1.58
6.4	3.59	3.63	3.73	1.67	1.65	1.61
6.6	3.65	3.68	3.78	1.70	1.68	1.64
6.8	3.70	3.73	3.83	1.73	1.71	1.67
T(PI) = PLAB - .138 GEV						
7.0	3.75	3.78	3.87	1.75	1.74	1.70
7.2	3.80	3.83	3.92	1.78	1.76	1.72
7.4	3.85	3.88	3.97	1.81	1.79	1.75
7.6	3.89	3.93	4.02	1.83	1.82	1.78
7.8	3.94	3.97	4.06	1.86	1.84	1.80
T(PI) = PLAB - .138 GEV						
8.0	3.99	4.02	4.11	1.88	1.87	1.83
8.2	4.04	4.07	4.15	1.91	1.89	1.85
8.4	4.08	4.11	4.20	1.93	1.92	1.88
8.6	4.13	4.16	4.24	1.95	1.94	1.90
8.8	4.17	4.20	4.29	1.98	1.96	1.93
T(PI) = PLAB - .138 GEV						
9.0	4.22	4.25	4.33	2.00	1.99	1.95
9.2	4.26	4.29	4.37	2.03	2.01	1.97
9.4	4.31	4.33	4.41	2.05	2.03	2.00
9.6	4.35	4.38	4.46	2.07	2.06	2.02
9.8	4.39	4.42	4.50	2.09	2.08	2.04
T(PI) = PLAB - .139 GEV						
10.0	4.43	4.46	4.54	2.12	2.10	2.07
10.5	4.54	4.57	4.64	2.17	2.16	2.12
11.0	4.64	4.67	4.74	2.22	2.21	2.18
11.5	4.74	4.77	4.84	2.28	2.26	2.23
12.0	4.84	4.86	4.93	2.33	2.31	2.28
T(PI) = PLAB - .139 GEV						
12.5	4.94	4.96	5.03	2.38	2.36	2.33
13.0	5.03	5.05	5.12	2.43	2.41	2.38
13.5	5.12	5.15	5.21	2.47	2.46	2.43
14.0	5.21	5.24	5.30	2.52	2.51	2.48
14.5	5.30	5.32	5.39	2.57	2.56	2.53
T(PI) = PLAB - .139 GEV						
15.0	5.39	5.41	5.47	2.61	2.60	2.57
16.0	5.56	5.58	5.64	2.70	2.69	2.66
17.0	5.73	5.75	5.81	2.78	2.77	2.75
18.0	5.89	5.91	5.97	2.87	2.86	2.83
19.0	6.05	6.07	6.12	2.95	2.94	2.91
T(PI) = PLAB - .139 GEV						
20.0	6.20	6.22	6.27	3.03	3.02	2.99
22.0	6.49	6.51	6.56	3.18	3.17	3.14
24.0	6.78	6.79	6.84	3.32	3.31	3.29
26.0	7.05	7.07	7.11	3.46	3.45	3.43
28.0	7.31	7.33	7.37	3.59	3.59	3.56
T(PI) = PLAB - .139 GEV						
30.0	7.56	7.58	7.62	3.72	3.71	3.69
32.0	7.81	7.82	7.86	3.85	3.84	3.82
34.0	8.04	8.06	8.10	3.97	3.96	3.94
36.0	8.27	8.29	8.33	4.08	4.08	4.06
38.0	8.50	8.51	8.55	4.20	4.19	4.17
T(PI) = PLAB - .139 GEV						
40.0	8.72	8.73	8.77	4.31	4.30	4.28
42.0	8.93	8.94	8.98	4.41	4.41	4.39
44.0	9.14	9.15	9.18	4.52	4.51	4.50
46.0	9.34	9.35	9.39	4.62	4.62	4.60
48.0	9.54	9.55	9.58	4.72	4.72	4.70
T(PI) = PLAB - .139 GEV						
50.0	9.73	9.74	9.78	4.82	4.81	4.80
55.0	10.20	10.21	10.25	5.06	5.05	5.04
60.0	10.65	10.66	10.69	5.28	5.28	5.26
65.0	11.08	11.10	11.12	5.50	5.50	5.48
70.0	11.50	11.51	11.54	5.71	5.71	5.69
T(PI) = PLAB - .139 GEV						

CONFIDENCE LEVEL VS. χ^2 FOR n_D DEGREES OF FREEDOM



For any n_D, $\langle\chi^2\rangle = n_D$, $\delta(\chi^2) = \sqrt{2n_D}$. For large n_D, χ^2 becomes normally distributed about n_D. Thus in the notation of the box in the figure,

$$y_1 = (\chi^2 - n)/\sqrt{2n_D} \text{ has unit s. d.}$$

A better approximation, due to Fisher,† is that χ, not χ^2, is normally distributed, specifically

$$y_2 = \sqrt{2\chi^2} - \sqrt{2n_D - 1} \text{ has unit s. d.}$$

One sees then that y_1 underestimates small C. L.'s. Thus for $n = 50$ and $\chi^2 = 80$, $y_1 = 3.0$ and C. L. = 0.13% vs $y_2 = 2.7$, C. L. = 0.35%.

†R. A. Fisher, "Statistical Methods for Research Workers," Oliver and Boyd, Edinburgh.

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For $n > -1$ but not necessarily integral:

$$\int_0^\infty x^{2n+1} \exp\left[-\frac{x^2}{2\sigma^2}\right] dx = 2^n n!\, \sigma^{2n+2}; \ (\tfrac{1}{2})! = \sqrt{\pi}/2$$

Relation between standard deviation σ and mean deviation α:

$2\sigma^2 = \pi\alpha^2$; σ = 1.4826 probable error

Odds against exceeding one standard deviation = 2.15:1; two, 21:1; three, 370:1; four, 16,000:1; five, 1,700,000:1.

Atomic and Nuclear Properties of Materials

Material	Z	A	Cross Section σ^a barns	Collision Length L_{coll} [b] g cm^{-2}	cm	Minimum $-dE/dx$ [c] MeV g^{-1} cm^2	MeV cm^{-1}	Radiation Length L_{rad} [d] g cm^{-2}	cm	Density ρ g cm^{-3}
H_2	1	1.01	0.063	26.5	374	4.13	0.292	58.0	819	0.0708[e]
D_2	1	2.01	0.100	33.4	202	2.07	0.342	116	703	0.165[e]
He	2	4.00	0.16	42.0	336	1.94	0.242	85.4	683	0.125[e]
Li	3	6.94	0.23	50.4	94.3	1.69	0.902	78.7	148	0.534
Be	4	9.01	0.28	55.0	29.9	1.60	2.96	63.7	34.7	1.848
C	6	12.01	0.33	60.4	f	1.78	f	42.4	f	≈1.55[f]
N_2	7	14.01	0.36	63.6	78.9	1.81	1.46	37.8	46.7	0.808[e]
Ne	10	20.18	0.465	72.1	60.1	1.73	2.08	29.1[i]	24.2[i]	1.200[e,k]
Al	13	26.98	0.57	79.2	29.3	1.62	4.37	24.0	8.9	2.70
Fe	26	55.85	0.92	101.2	12.8	1.48	11.6	13.9	1.8	7.87
Cu	29	63.54	1.00	105.4	11.8	1.44	12.9	12.0	1.34	8.96
Sn	50	118.69	1.55	129.7	17.8	1.28	9.4	8.89	1.22	7.31
W	74	183.85	2.02	150.8	7.80	1.17	22.6	6.89	0.36	19.3
Pb	82	207.19	2.20	156.2	13.8	1.13	12.8	6.52	0.58	11.35
U	92	238.03	2.42	163.6	≈8.63	1.09	≈20.6	6.13	≈0.32	≈18.95
Air				64.6	53620	1.81	0.0022	36.5	30290	0.001205[g]
Freon (CF_3Br)				87.1	≈58.0	1.52	≈2.3	16.6	≈11	≈1.5
H_2 (bubble chamber, 27°K)				26.5	442	4.13	0.248	58.0	970	≈0.060[h]
H-Ne mixture (bubble chamber)[j]				67.3	96.1	1.83	1.28	29.8[i]	42.5[i]	.70
H_2O				57.2	57.2	2.03	2.03	35.7	35.7	1.00
Ilford Emulsion				103.0	27.0		5.49	11.2	2.91	3.815
Air				64.6	53620	1.81	0.0022	36.5	30290	0.001205[g]
Freon (CF_3Br)				87.1	≈58.0	1.52	≈2.3	16.6	≈11	≈1.5
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H_2O				57.2	57.2	2.03	2.03	35.7	35.7	1.00
Ilford Emulsion				103.0	27.0		5.49	11.2	2.91	3.815
LiF				63.8	24.2	1.69	4.46	39.0	14.8	2.64
Mylar ($C_5H_4O_2$)				59.1	42.8	1.91	2.64	39.6	28.7	1.38
NaI				119.0	32.4	1.32	4.84	9.58	2.61	3.67
Polyethylene (CH_2)				51.0	≈55.5	2.09	≈1.92	44.1	≈48	≈0.92
Polystyrene (CH) [*]				54.9	≈52.3	2.03	≈2.14	43.4	≈41.3	≈1.05
Propane (C_3H_8, bubble chamber)				48.9	119.3	2.28	0.935	44.6	109	0.41

a. $\sigma = \sigma_{natural} = \pi(\hbar/m_\pi c)^2 \times A^{2/3} = 62.8\ \text{mb} \times A^{2/3}$

b. $L_{coll} = A/(N\sigma_{natural}) = 26.5\ \text{g cm}^{-2} \times A^{1/3}$

c. From W. H. Barkas and M. J. Berger, Tables of Energy Losses and Ranges of Heavy Charged Particles, NASA SP-3013 (1964)

d. Mainly from High Energy and Nuclear Physics Data Handbook, W. Galbraith and W. S. C. Williams, Ed. (N. I. R. N. S., Rutherford Lab., Chilton, Didcot, Berks.) 1964

e. Liquid phase at 1 atm. and boiling temperature. f. density variable g. at 20°C

h. May vary by about ±3%, depending on operation conditions

i. From F. R. Huson, Ionization Loss, Range, Straggling and Multiple Scattering, BNL 11386 (1967)

j. 53.7 atomic percent Ne.

k. Density of gas at STP = 0.900×10^{-3} g cm^{-3}, i. e. 0.75×10^{-3} times the density (1.200) of the boiling liquid.

[*] Typical scintillator, e. g. PILOT B has H/C = 1.1.

MULTIPLE COULOMB SCATTERING[b]

The rms projected angle θ due to multiple Coulomb scattering (only) of a particle of charge z, momentum P, velocity V is

$$\theta_{proj} = z\, \frac{15(\text{MeV})}{PV(\text{MeV})} \sqrt{\frac{L}{L_{(rad)}}}\, (1+\epsilon) \text{ radians;}$$

where L = length in scatterer.

For $L \geq 1/10\ L(\text{rad})$ ϵ is generally $< 1/10$. The distribution of θ is not truly Gaussian.[c] The rms projected displacement y on traversing an absorber of thickness L is $y_{rms} = L\theta_{proj}/\sqrt{3}$.

RADIOACTIVITY

1 curie = 3.7×10^{10} disintegrations/sec

1 R = 87.8 ergs/g air = 5.49×10^7 MeV/g air

Fluxes (per cm^2) to liberate 1 R in carbon:

3×10^7 minimum ionizing singly charged particles

0.9×10^9 photons of 1 MeV energy.

(These fluxes are actually correct to within a factor of two for all materials.)

1 R of radiation, particularly for neutrons, may produce up to ~ 10 "rem" (R equivalent for man), even 20 "rem" for α and other heavy ions.

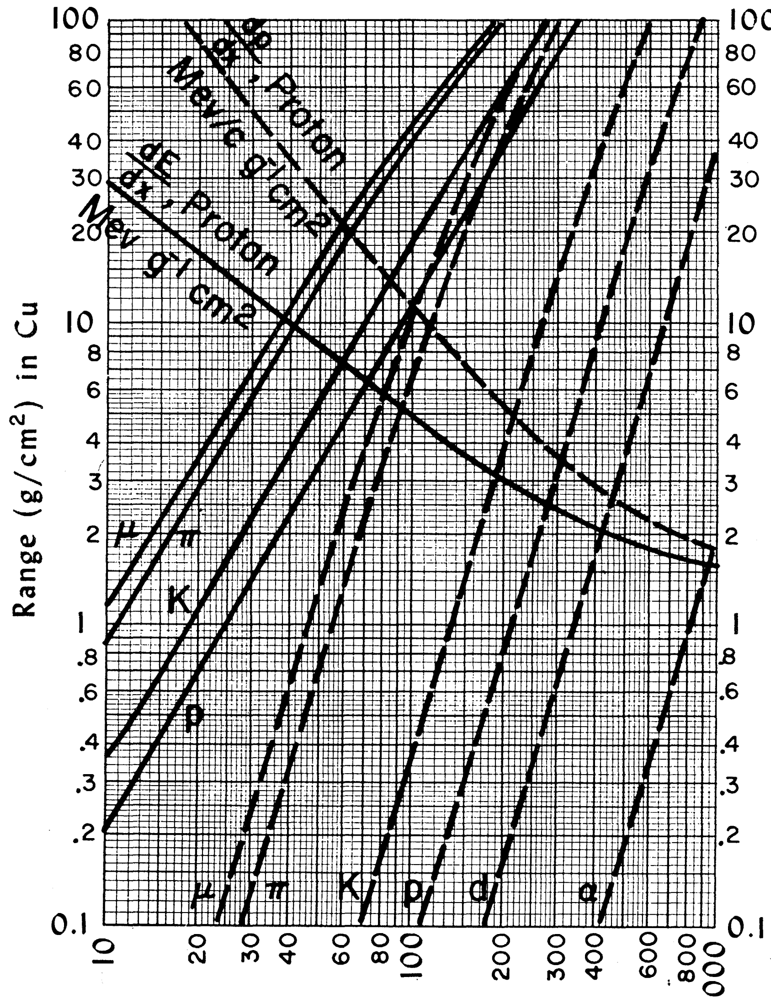
Natural background: 120 → 130 milirem/year divided as follows:

cosmic radiation	– charged part. + neutrons	~ 25	milirem/yr
" "	– γ	~ 25	" "
Rock and air	– γ	~ 73	" "

The permissible occupational dose for the whole body: 100 milirem/week, but 1.25 rem per calendar quarter.

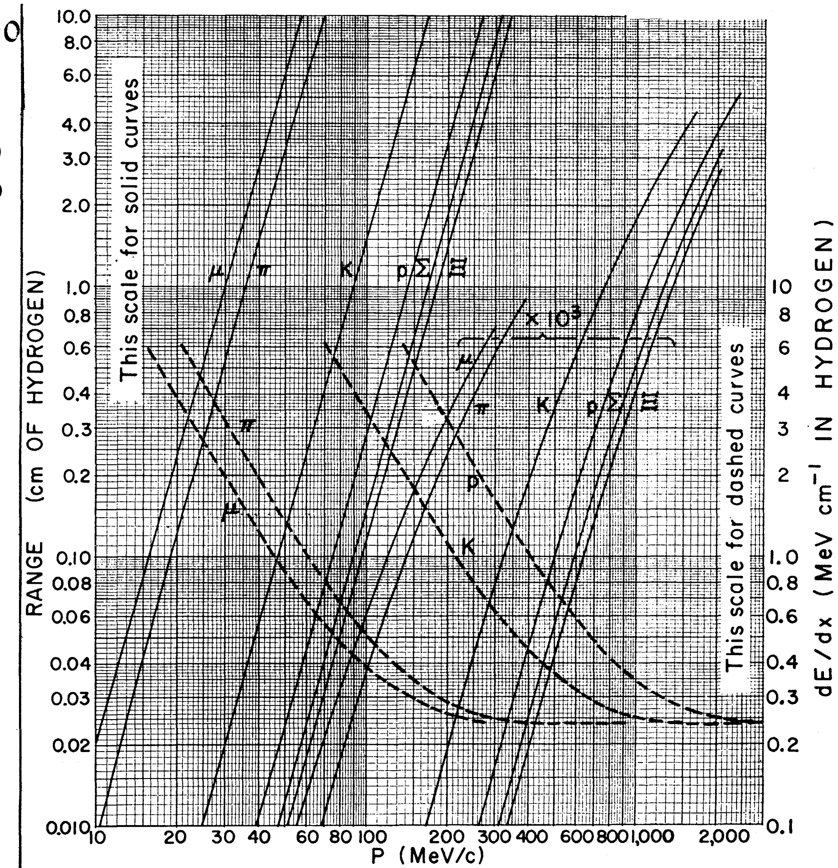
b. Mainly from G. Z. Molière, Naturforsch. 3 (a), 78 (1948).

c. See, for example, the experimental work of A. D. Hansen, L. H. Lanzl, E. M. Lyman and M. B. Scott, Phys. Rev. 84, 634 (1951).



——— Particle energy (Mev)

– – – – Particle momentum (Mev/c)



Ranges in liquid hydrogen bubble chamber, determined by a μ^+ range of 1.103 ± 0.003 cm from the $\pi^+ \rightarrow \mu^+ \nu$ decay. Liquid hydrogen conditions: $T = 27.6 \pm 0.1°$ K; $P = 48 \pm 5$ psia; $\rho = (5.86 \pm 0.06) 10^{-2}$ g/cm^3. (Data by Clark and Diehl.) Bubble chamber physicists note that the number of bubbles per cm is proportional to $1/\beta^2$, not to dE/dx.